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An International Study of Curricular Organizers

for the Study of Technology

by

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(ABSTRACT)

The purpose of the study was to identify the key descriptors of a definition of technology and curricular organizers for use in the study of technology. Seven panels were used for the three round Delphi to identify the key descriptors and curricular organizers. The panels included: (1) technology educators, (2) philosophers of education, (3) philosophers of technology, (4) historians of technology, (5) anthropologists of technology, (6) futurists, (7) industrialists/business leaders.

A Thurstone and Chave Method of Equal Appearing Intervals was used to assign scale and Q values to each item ranked in the Q sort. An 80th centile was used for an item to achieve a consensus. The results of both research questions were rank ordered based on scale value from highest to lowest. Fourteen key descriptors of a definition of technology obtained a consensus. These are innovation; invention; creative; extends human capabilities (physical, social ,and intellectual); a process (change, individual, corporate, design, creative, and systematic); extension of human potential; problem solving; purposeful human manipulation of the material world; closely linked to science but not simply applied science, body of knowledge; used to solve problems and create opportunities; played an important role in the emergence of *Homo sapiens*; a system of tools, knowledge, and behaviors associated with the exploitation of environments; and has social, economic, political, and environmental impacts. Seven curricular organizers achieved a consensus. These are problem solving; process organizers (creativity, enterprise, systems, inventions, and problem solving); the process of technology; design and innovation; reseach and development; and awareness of implications and potential of technology (health, food, communication, production, and control).

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CHAPTER I. INTRODUCTION

History and Background

> Possible curricular changes emanating from technological changes will require careful study and deliberation over a long period of time (*Educating Americans for the 21st Century, 1983, p 13*).

Education in this decade has been dominated by the thrust for excellence in education. Numerous recent reports have called for a complete reform of our total education process. State after state have echoed the report, *A Nation At Risk*, to overhaul their education system. Pervasive throughout these reform movements has been the importance of the study of technology as an essential element for a technologically literate citizenry.

In *Educating Americans for the 21st Century*, the report stressed the importance of technology education directed toward the needs of our future citizens.

> Students must be prepared to understand technological innovation, the productivity of technology, the impact of the products of technology on the quality of life, and the need for critical evaluation of societal matters involving the consequences of technology (p. 44).

Ernest L. Boyer, in the Carnegie Foundation for the Advancement of Teaching Report titled *High School: A Report on Secondary Education in America* (1983) cited the need for the study of technology that would lead to a more technologically literate citizenry.

> We recommend that all students study technology: the history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised (p. 110).

Bell (1973) identified that society has transcended from machine technology to an intellectual technology (p. 27). Logically, this affects the way curricular organizers for the study of technology should be identified to appropriately represent the study of technology. The present curricular organizers for technology education, construction, manufacturing, communication, and transportation, do not appropriately represent an intellectual technology that is advancing exponentially.

These curricular organizers were derived from an industrial base. Although the industrial implications for industrial arts can be traced back to the Industrial-Social Theory or the Russell-Bonser Plan, Warner's curriculum organization has been the most widely accepted within the industrial arts profession (Snedden and Warner, 1927, pp. 7-8). Warner identified the same four curricular organizers, manufacturing, construction, communication, and transportation, for the study of industrial arts. The research and development done by Warner and his associates reflect the technology of post-World War II. Interestingly enough, Warner's selection of these four curricular organizers was based on his continuous monitoring of census and economic data, beginning in 1925 (p. 5). Warner's curriculum was designed to be taught in what he termed a "laboratory of industries" (Department of Practical Arts and Vocational Education, 1930).

Wilber (1948) looked at industrial arts' role in general education. He defined industrial arts as:

> those phases of general education which deal with industry - its organization, materials, occupations, processes, and products - and with problems resulting from the industrial and technological nature of society (p. 2).

In organizing his three objectives of general education, Wilber used the term industrial as a curricular organizer for transmitting a way of life. The implications for industrial arts stated by Wilber reflected the thinking of Warner.

Olson (1963), a student of Warner, classified industrial arts' subject matter through an industries analysis. His analysis identified eight categories of industries: manufacturing, construction, power, transportation, electronics, research, services, and management (p. 95).

The numerous curriculum projects of the 1960's, influenced by Sputnik an the federal and private legislation that followed, emphasized industrial arts' curriculum to be organized with an industrial base. The Industrial Arts Curriculum Project (1966) organized the study of industrial technology under two major organizers: manufacturing and construction. Likewise, curriculum projects such as the American Industry Project (1968), the Functions of Industry (1962), the Georgia Plan (1967), the Industriology Project (1968), and the Orchestrated Systems Approach (1968) all reflect similar industrial curricular organization of Warner.

The Jackson's Mill Industrial Arts Curriculum Symposium (1981) adopted construction, manufacturing, communication, and transportation as their curricular organizers. The Technical Foundation of America study and guide, *Industry and Technology A Guide for Curriculum Designers, Implementation, and Teachers* (1984), also used the same four industrial curriculum organizers.

LaPorte (1986) identified six challenges that the technology education profession must meet. Among these are that:

> a clear definition of technology education must be communicated to the various constituencies which are to be served, the current major organizers of production, communication, and transportation must be discarded or revised because they are inclusive of industrial technology, not technology *in toto*, the relationship of technology education to related programs must be established and clarified, and the advantage of teaching the "how to" aspects of technology must be irrefutably defended and delineated (LaPorte, 1986, pp. 71-72).

To date, there has not been a study conducted to determine the appropriate curricular organizers for the study of technology relative to its future nature and how technology will be learned. Therefore, it is necessary to examine this crucial issue.

Statement of the Problem

The problem of this study stems from the vast misunderstanding or broad interruptations as to what technology is and what the study of technology encompasses. Therefore, the purpose of this study is to identify key descriptors of a definition for technology and the appropriate curricular organizers for the study of technology.

Research Questions

The research questions in this study included:

1. Looking into the future, what will be the appropriate definition for technology?

2. Looking into the future, what will be the appropriate curricular organizers for the study of technology?

Significance of Study

Herbert Spencer wrote "before there can be a rational curriculum, we must settle which things concern us most to know; we must determine the relative value of knowledge" (Spencer, 1911, p. 7). This is an important principle for the technology education profession to understand during a transition from industrial arts to the study of technology. However, with the association's name change from the American Industrial Arts Association to the International Technology Education Association in 1985 to better reflect the study of technology, the curriculum organization did not change. In other words, the curricular organizers, communication, construction, manufacturing, and transportation, represent only one phase of the study of technology, industry.

In a recent article, Dugger called for the need to research and identify appropriate curricular organizers to reflect the study of technology (Dugger, 1985, p. 2). Maley, in his keynote address at Technology Symposium VII, agreed with Dugger by challenging the technology profession with a three-part curriculum, involving the content, the individual (student), and the society. Maley stated that curriculum has been "largely content taxonomies or content delineations with little concern for the student and their internal goals, as well as the human quality needs of society" (Maley, 1985, p. 10). In his speech, Maley also called for a concensus on an operational definition for technology education (Maley, 1985, p. 3).

In a paper presented at the Mississippi Valley Industrial Teacher Education Conference in 1985, Squier challenged the members that the present curricular organizers for the study of technology were delimiting and that they did not appropriately represent the study of technology. In this paper, Squier stated that skill development is not the primary purpose of technology education and technology education should not focus upon technical content. The emphasis should be upon knowledge, skills, and attitudes essential for all students to live and interact in the artificial, human-made world (Squier, 1985, pp. 6-7). Problem-solving and concept development through a holistic approach are the key components of technology education.

Numerous excellence in education reports issued in recent years have called for drastic educational reform. Most reports agree that three subjects are essential for all youth's education, science, mathematics, and technology education. However, their reference to technology education is not one of the vocational curriculum, but rather a general education curriculum. The reports, for the most part, recommend that technology education must be interdisciplinary, utilizing a problem-solving and critical thinking approach to integrate and apply other discipline content.

The National Science Foundation Report (1983) stated that "technology topics need to be integrated into the present curriculum. This includes science and mathematics classes, industrial arts, social studies and the language arts, and art and music" (p. 75). Boyer, in the Carnegie Foundation for the Advancement of Teaching Report, *High School: A Report on Secondary Education in America*, (1983) cited the need for technology education that would lead to a more technologically literate citizenry (p. 11).

Shane identified twenty-eight cardinal premises for educational change that stressed the need to organize curriculum in a holistic, life-long process that fosters interdisciplinary problem-solving and critical thinking activities (Shane, 1977, pp. 59-68). The school of the future should embrace technology to encourage creativity, problem-solving, efficiency, and controlling the world (Shane, 1981, pp. 351-356). Bell concurs with Shane when he outlined the need to reorganize curriculum to better learn "intellectual technology" (Bell, 1973).

Truly, if technology education is to play a key role in preparing a technologically literate citizenry, its curriculum organization must be studied to appropriately identify and gain concensus on the curricular organizers for the study of technology and the key descriptors of a definition for technology. It is therefore significant that this research study will accomplish this.

Definition of Terms

Technology. Technology is that branch of knowledge that deals with the industrial arts, applied science, engineering; the terminology of an art, science; technical nomenclature; a technological process, invention, method or the like; the sum of ways in which a social group provides themselves with the material objects of their civilization (*The Random House Dictionary*, 1967). "In its simplest terms, technology is man's efforts to cope with his physical environment--both that provided by nature and that created by man's own technological deeds, such as cities--and his attempts to subdue the control that environment by means of his imagination and ingenuity in the use of available resources" (Kranzberg and Pursell, 1967, pp. 4-5).

Technology Education. Technology Education is a comprehensive, action-based educational program concerned with technical means, their evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their social/cultural impacts (International Technology Education Association, 1986).

Technological Literacy. Technological literacy is defined as "an understanding of technology and its dynamics, the opportunities it offers, and its impact on product and process, markets, organization structures and people" (Drucker, March 26, 1985).

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Technological Literacy. Technological literacy is defined as "an understanding of technology and its dynamics, the opportunities it offers, and its impact on product and process, markets, organization structures and people" (Drucker, March 26, 1985).

Curriculum. "The curriculum is the plans made for guiding learning in schools, usually represented in retrievable documents of several levels of generality, and the implementation of those plans in the classroom; those experiences that take place in a learning environment that also influences what is learned" (Glatthorn, 1987, p. 1).

Key Descriptor. It is a word or phrase that represents a unique element or common element of a definition of technology.

Curriculum Organizer. A curricular organizer is a word or phrase that identifies a major category of a field of study. These curricular organizers must reflect the content of a field of technology, must cover the total field of technology, and must have as little overlap as possible.

Content Organizer. It is a term or element that categorizes a field of study as subject matter, material, or technology.

Process Organizer. It is a term or element that categorizes a field of study methods, concepts, or procedures.

Delphi Technique. A method for the systematic solicitation and collection of expert opinion (Helmer, 1966, p. 1).

Method of Equal Appearing Intervals. It is a Q sort technique used in obtaining scale values for a large number of statements by making comparative judgments for each statement (Edwards, 1957, p. 83).

Limitations of the Study

The research study was circumscribed by the following limitations:

1. The study was limited to seven panels, consisting of five experts each.
2. The selection of the panels of experts was limited to a modified citation process.

3. The panels of experts were limited to technology education professionals, futurists, industrialists/business leaders, historians of technology, anthropologists of technology, and philosophers of technology, and philosophers of education.
4. The research study was limited to the examination of what will be th key descriptors of a definition for technology and what will be the appropriate curricular organizers for the study of technology.
5. The Delphi technique and the Method of Equal Apearing Intervals were the only methods used to gain consensusof the experts on the research topics studied.

Assumptions of the Study

The study was based on the following assumptions:

1. The study of appropriate curricular organizers for the study of technology is a viable study for the discipline of technology education.
2. The Delphi technique and the Method of Equal Apearing Intervals were an acceptable method for the purposes of this study.
3. The selection process for panel experts was appropriate for this study.
4. The experts selected to serve on each panel were well qualified as members of that particular panel.
5. The responses of the experts could be categorized under one of the two research questions of this study.

Summary

In Chapter I, the purpose of the study, the statement of the problem, the research questions to be answered in the study, the significance of the study, definitions of terms commonly used in the study, the limitations of the study, and assumptions associated with the study were presented.

The results of the study will be reported in additional chapters. The review and synthesize the literature relative to the topic of study will be presented in Chapter II. This will include a description of what technology is, a description of what technology education is, a historical perspective of curriculum organizers outside technology education, a historical perspective of curriculum organizes within industrial arts/technology education, an international perspective of curricular organizers within technology education, and a review of the Delphi Technique.

The design of the study will be delineated in Chapter III. This will include the organization of the Delphi Technique employed during the study, data collection, and research analysis. The research findings and the analysis of data will be presented in Chapter IV. The research findings and conclusions based on the findings will be summarized in Chapter V. Implications and recommendations will be presented for future research.

CHAPTER II. REVIEW OF LITERATURE

The purpose of Chapter II is to review the literature relative to the research topic. Included are an examination of what technology is; what technology education is; a historical perspective of curricular organizers outside Industrial Arts/Technology Education; a historical perspective of curricular organizers within Industrial Arts/Technology Education; an international perspective of curricular organizers within Technology Education; and the Delphi Technique.

What is Technology?

The word "technology" derives its etymological origin from the Greek work *technologia*, with its roots *techne* and *logos*. *Techne* was interpreted to mean craft or skill (Hesiod, 1914, pp. 91 and 135). *Logos* was connoted to mean discourse or treatise (Liddell and Scott, 1884, p. 901).

Aristotle examined the relationship between *techne* and *logos*. He clarified the relationship of techne and logos to *episteme* (scientific knowledge). Aristotle classified the term *episteme* into three categories: *theoretike* (theoretical science), *praktike* (practical science), and *poietike* (productive science). From this classification, Aristotle derived the term *technologia* to mean the systematic treatment of rhetoric (Aristotle, 1926, pp. 3 and 13).

Theoretike focused on things that exist out of necessity. "For everything that exists of necessity in an unqualified sense is eternal and what is eternal is ungenerated and imperishable and hence cannot be otherwise." *Praktike* referred to "things made", while *poietike* referred to "things done". *Praxis* identified the action of "what man does", *poiesis* defined production or "what man brings into being" (Aristotle, 1962, pp. 150-153). To Aristotle, *praxis* was of a higher order than *poiesis*, "we consider that science which is desirable in itself and for the sake of knowledge is more nearly Wisdom than that which is desirable for its results" (Aristotle, 1961, p. 11).

Interestingly, not until Bacon's idea of a comprehensive history had been published did the Greek term *technologia* become associated with the mechanical arts (Kasprzyk, 1973, p. 58). Beckmann (1846) used the term *technologie* that was basically synonymous with the Greek term *technologia* (Kasprzyk, 1973, p. 60). Beckmann was interested in the practical application of knowledge through a systematic process (Beckmann, 1846, p. xx).

Bigelow's book (1829), *Elements of Technology*, marked the first time the word technology was used in American literature with reference to the mechanical-industrial arts (Oliver, 1956, p. 146).

> I have adopted the general name Technology, a word sufficiently expressive, which is found in some older dictionaries, and is beginning to be revived in the literature of practical men at the present day. Under this title it is attempted to include an account as the limits of the volume permit of the principles, processes, and nomenclatures of the more conspicuous arts, practicularly those which involve applications of science, and which may be considered useful, by promoting the benefit of society, together with the emolument of those who pursue them (Bigelow, 1829, pp. iv-v).

Bigelow concentrated his work on the mechanical arts and on those fine arts related to industrial production.

As a springboard from the derivation of the term technology to the many practical definitions of the word, it is important to examine several dictionary definitions of technology. *Webster's Seventh New Collegiate Dictionary* (1970) defines technology as "(1) technical language; (2a) applied science (b) the totality of the means employed to provide objects necessary for human sustenance and comfort" (p. 905).

The *Dictionary of Education* (1973) defines technology as "(1) the systematic scientific study of technique; (2) the application of science to the solution of practical problems; (3) a systematic body of facts and principles comprehensively organized for a practical purpose; may include the principles of effective teaching; (4) the science or systematic knowledge of the industrial arts; especially as applied to manufacturing; (5) the material culture resulting from the combination of logic, mathematics, and science" (Good, p. 592).

The *McGraw-Hill Encyclopedia of Science and Technology* (1966) defines technology as "systematic knowledge and action, usually of industrial processes but applicable to any recurrent activity" (p. 406).

Technology has been defined in many ways relative to education or special interest group. Skolimowski (1966) wrote

> There is a tendency to identify technology with a demiurge of our times, or perhaps even with a Moloch who will bring doom to mankind, that is, mankind as dreamt of by philosophers, not by organization men. In this setting technology assumes a role similar to that which was ascribed to history in the nineteenth century: the role of the final cause which shapes the destiny of mankind and, more specifically, which aims at the total subjugation of man to the machine or, in other words, at turning the human being into a technological component (p. 371).

Defining technology has lead to much confusion and a lack of a clear understanding as to what the word "technology" actually means. Many groups have used to term "technology" in many different contexts. Mitcham (1978) pointed out the confusion with defining technology. He identified four broad categories for defining technology: (1) technology-as-object, (2) technology-as-process, (3) technology-as-knowledge, and (4) technology-as-volition (pp. 229-294). He related these four categories to the ways that engineers and social scientists view technology. Sinclair and Tilston (1982) also examined the relationship of technology to engineering. They pointed out the importance to understand the relationship between technology and engineering, but it was difficult due to the lack of a clear definition of the philosophy of engineering (p 96). DeVore (1985) also concluded that there is much confusion in distinguishing between science and technology (p. 6).

Morris (1977) contended that "technology exists in a context, which includes ideology and which may undermine the claims of technological determinism. This context can be elucidated by contrasting present-day mass society with a tribal organization of society. Central to this is an examination of the way in which ideology and myth differ in their use of language, their impact on the community, and their treatment of special interests (p. 395).

Technology has also been viewed as a spectrum. On the one end are the ideas, while techniques fall at the other end, with design representing the midpoint. To Layton, this serves to integrate the history of technology to other branches of intellectual and social history. (Layton, 1974, pp. 37-38 and 41). Feibleman held that "skills are components of technology...Every undertaking has its special technology, its tools, and the skills to use them. Technology is the material side of an enterprise, the discipline which is equally necessary at every level (Feibleman, 1966, pp. 319-320).

Others view technology as applied science. Bunge (1966) contended that technology "suggests the study of practical arts rather than a scientific discipline and applied science suggests the application of scientific ideas rather than that of the scientific method" (p. 329). Agassi's work (1966) supports that of Bunge. He examined the confusion that exists between science and technology. He concluded that technology includes applied science, invention, implementation of results of both applied science and invention, and the maintenance of the existing apparatus, especially in the face of unexpected changes and disasters. On the other hand, applied science deals with two kinds of problems: deduciblity and applicability (pp. 348 and 360). In other words, Agassi was interested in the utility of that knowledge for practical application. Bame and Lutz (1970) agreed that applied science is a part of technology (p. 321).

Lenk (1980) stated that:

> Science emphasizes the scope and range of theories or the depth of the questions they raise, opportunities for more precise measurement, verisimilitude or a close fit with reality, elimination of anomalies, the opportunity for theoretical integration at the comprehensive level,

venturesome-even speculative-new approaches, favorable outcomes relative to competing theories, even new epistemological paradigms of a basic philosophical sort. For, technology, the story is different, with emphasis on durability, reliability, standardization, routinization, efficiency, quick payoff, practicality, lucidity, functional appropriateness, model construction, and cost-effectiveness (Lenk, 1984, p. 42).

Koyre reviewed the relationship between science and technology as technology not being reduced to techniques, but as a system of thought, different that of science. Interestingly, Koyre believed than that science did influence technology (Layton, 1974, pp. 35-36).

Gruender (1969) distinguished between applied science and technology by examining the problem assigned. To him, people who view problems with a broad scope are concerned with applied science, while those who view problems in a more specific context are concerned with technology (p 461). In discussing the relationship between science and technology, Price (1984) emphasized that with science one looks to the process by which paradigms are broken, while with technology one looks for the source of unexpected innovation (p. 6).

Lux (1983) distinguished between science and technology relative to its relationship to industrial arts. "As a school subject, science offers a systematic study of knowledge about nature, while technology is a systematic study of how people alter nature to make it of more use or value (pp. 9-10).

Another view of technology is praxiology. Simply defined, it is the study of the science of efficient action. Kotarbinski (1965) stated

> The praxiologist concerns himself with finding the broadest possible generalizations of a technical nature. His objective is that good technique, efficient work such as indications, and warnings important for all work which is intended to achieve maximum effectivness... It is clear, therefore, that in my opinion the principal concerns of praxiology consists in the formulation and justification of standards appropriate to efficiency. That practical concern, however, requires support in the form of practical experience, the result of toil and struggle of innumerable agents. (pp. 1-2).

Others have concentrated on the appropriateness of technology. Skolimowski (1970) emphasized that "the totality of all manmade tools, their function and use, the material products resulting from the application of tools and the knowledge of their function, social impact of the products, and the influence of technological change on the lives of particular individuals" (p. 35). Van Brakel (1980) examined various definitions of appropriate technology and its criteria. He concluded that a systems approach provided a unified way of studying appropriate technology (pp. 385-398).

Carpenter (1983) looked at appropriate technology in the context of alternative technology. He concluded that alternative technology should be promoted as a political instrument. "And, since our technologies contain a democratic potential for community self-determination, we may look to the time when informed human deliberations, and not technology, regain their capacity to structure and guarantee a human existence" (pp. 30-31).

Todd (1985) defined appropriate technology in the terms of the use of technology as a country grows and matures. He identified five levels of development and their characteristic. The indigenous level is characterized by traditional technology. The second level, emerging, is characterized by technology transfer. The third level, developing is characterized by appropriate technology. The fourth level, industrialized, is characterized by technical systems. The final level, cybernetic, is characterized by integrated technological systems.

Singer, Holmyard, and Hall, looking at technology from a historical perspective, defined technology as "how things are commonly done or made, what things are done or made" (1954, p. vii). Kranzberg and Pursell (1967), also defining technology from a history of technology viewpoint, stated that technology "is much more than tools and artifacts, machines and process. It deals with *human work*, with man's attempts to satisfy his wants by human action on physical objects" (Kranzberg and Pursell, p. 6). Dumas (1962) contended that technology defined from a historical viewpoint is the "description of techniques and their development (pp. 1-9).

From an anthropological point of view, Lechtman and Steinberg (1979) defined technology as "a subsystem of culture" (p. 136). Merrill stated that "technologies are the cultural traditions developed in human communities for dealing with the physical and biological environment...[they] are important not only because they affect social life but also because they constitute a major body of cultural phenomena in their own right" (Merrill, 1968, pp. 577, 582). Gehlen (1983) stated that anthropological technology as "related to the natural sciences, on the one hand, and to industrial machine production, on the other, with a complicated relationship of mutual influences. And these three spheres, of course, along with the entire sphere of information, can be seen as a *superstructure*, the existence of which constitutes the primary difference between our culture and all previous cultures" (p. 207).

Skolimowski (1966) pointed out the differences between the philosophy of technology and technological philosophy. The philosophy of technology "belongs to the realm of epistemological inquiry and attempts to situate technology within the scope of human knowledge; the latter belongs to the realm of sociology, broadly conceived, or social philosophy, and is concerned primarily with the future of human society" (Skolimowski, 1966, p. 371).

Brinkmann (1945) argued that "technology is not just applied science, that it is more concerned with the construction of real commodities. But this means that the essential feature of technology lies in that irrational, emotional impulse which simultaneously conceals and reveals itself in design and invention no matter how rational and purposive they may appear" (p.80).

Relative to education, the term technology has a long history and has taken on many meanings through its history. Dewey (1929) argued that:

> There is no difference in logical principle between the method of science and the method pursued in technologies. The difference is practical, in the scale of operations conducted, in the lesser degree of control through isolation of conditions operative, and especially in the purpose for the sake of which regulated control of modifications of natural existence and energies is undertaken; especially, since the dominant motive of large scale regulation of the course of change is material comfort or pecuniary gain. But the technique of modern industry, in commerce, communication, transportation and all the appliances of light, heat, and electricity, is the fruit of the modern application of science. And the so-called "application" signifies the same kind of intentional introduction and management of changes which takes place in the laboratory is induced in the factory, the railway and the power house (pp. 84-85).

Warner was the first to define technology as a school discipline. From his initial definition of industrial arts relative to the "Laboratory of Industries" (Western Arts Association, 1933), Warner, along with a group of graduate students gave us the following definition of industrial arts.

> A general and fundamental school subject in a free society concerned with providing experiences that will help persons of all ages and both sexes to profit by the technology, because all are involved as consumers, many as producers, and there are countless recreational opportunities for all (Warner et al., 1952, p. 5).

Schad also defined industrial arts relative to the study of technology.

> An essential area of general education in which persons of all ages study the materials, products, tools, machines, processes, occupations, organization and human problems of industry for the purpose of achieving the functions of exploration, guidance, avocation, consumer knowledge, social and economic understanding, technical and scientific knowledge, and cultural and aesthetic appreciations. It is a field which stresses learning through the manipulation of materials, supplemented by experiences requiring creative planning, problem solving, observations, visits, discussions, readings, experiments, reports, analyses, and leadership and followership opportunities. In brief, it is the study of the technology of a democratic society (Schad, 1946).

Giachino and Gallington's (1961) definition of industrial arts also reflected technology, and paralleled Warner's and Schad's definition of industrial arts (p. 25). Olson developed several definitions of industrial arts relative to technology that were outgrowths of the thinking of Warner. Olson defined technology as:

> Technology is the many-faceted phenomenon in material created and advanced by man to free himself from enslavement by nature, but which, when undisciplined, enslaves its own creator. Following are several of its identities. Technology is the material culture. It is the total of what man knows about and does with materials. It has a history as old as pre-man and a future as great as man's imagination.
>
> Technology is man creating his own environment on earth, in air, in space, and in the sea, enabling him to live where he will.
>
> Technology is man gaining advantage over nature. It is his means to taming a hostile nature. He provides his own climates, travel, and communications; creates materials; replaces muscle power with machines-none of which nature did for him.

Technology is man creating his own culture. Technological developments have an impact on and affect the social, economic, moral, political, and environmental aspects of living. As technology advances, culture changes.

Technology is man expressing himself with materials, tools, machines, and energies. Such expression is as natural with him as is expression with words.

Technology is man making himself. Man is by nature a maker and creator. The technology which he creates impacts on him, changes his ways of thinking, doing, and living, as well as his values, standards, and concerns. Thus, it is the most powerful force created by man. Technology is the goods and services and the production thereof as today's industries (Olson, 1972, pp. 34-35).

Luetkemeyer (1968), in the 17th Yearbook of the American Council on Industrial Arts Education, examined people's relationship to technology, and the evolution of technology among other topics. He concluded that industrial arts is dependent upon industry for its content. Orlando (1972) researched the study of technology in which he defined technology as "a master system which deals with man's work." It is composed of individual technologies and, in its totality, consists of two variables (technical characteristics and social/cultural characteristics) and one constant (man) engaged in concurrent interaction (p. 8).

Kasprzyk (1973) conducted exhaustive research to clarify the definition of technology and the technology base for industrial arts. His conclusion was that technology and its study should be derived from the field of engineering (p. 142). He related the different content areas of industrial arts (communication, construction, manufacturing, and transportation) to different branches of engineering. Halfin (1973) defined technology as a series of processes. He recommended that a three dimensional matrix be developed to show the relationship between industrial arts content and the processes of technology. Halfin also recommended further research be done on each of the processes identified in his study.

DeVore (1980) discussed the importance of going beyond viewpoints and definitions of technology. In synthesizing the viewpoints and definitions of technology, he identified four constants:

1. that technology is an intellectual endeavor, a creation of the human mind, based on knowledge and procedures which are cumulative;
2. that there is a direct interrelationship between the nature and character of technology and society;
3. that there is a direct and positive relationship between technology and the evolution of mankind; and
4. that the control of tools, machines, techniques, and technical systems for the enhancement of human beings will require the study of the behavior of technological, social, and ideological systems and their interrelationships (p. 220).

From these constants, DeVore (1980) identified four specific categories in which to study technology:

1. Epistemological - concerned with the creation and development of knowledge;
2. Sociological - provides insight and information about relationships which exist between technology and society with respect to the origin, development, organization, and functioning of human society;
3. Anthropological - is the study of the physical creations of human mankind and the nature and essence of humankind as the creator of technology; and
4. Phenomenological - is focused on the behavior of systems - ideological, social, and adaptive - and on the relationships between the systems (pp. 220-221).

Toffler (1980) defined the evolution of technology through three waves. The First Wave was characterized by mankind inventing for necessity. Mankind used rudimentary levels of technology for this development. The Second Wave was characterized by the rebirth of science and the industrial society. The Third Wave was characterized by the birth of the information age.

Naisbitt (1982) identified three stages of technological development that must be understood in the study of technology. "First, the new technology or innovation follows the line of least resistance; second, the technology is used to improve previous technologies; and third, new directions or uses are discovered that grows out of technology itself."

The Jackson's Mill Industrial Arts Curriculum Project clarified the definition of technology for the industrial arts/technology profession.

> Technology is considered as the knowledge and study of human endeavors in creating and using tools, techniques, resources, and systems to manage their man-made and natural environment for the purpose of extending human potential and the relationship of these to individuals, society, and the civilization process (1983, p. 2).

In summary, since its Greek derivation, the term "technology" has been used by many groups and interpreted in many contexts. It has been defined as applied science and has been related to engineering. Technology has been associated with tools, materials, and processes. Others have viewed technology as appropriate technology, while others have expressed it as a subsystem of culture. Still others identify technology as praxiology. From the Jackson's Mill definition and the study of the Industry and Technology Education Project, a definition was defined for the industrial arts/technology education profession. This examination of what technology has provided a foundation from which the study of technology has been defined and used for educational purposes. The next section will investigate what technology education is. It will highlight the role of technology education in public education and its implications for the educational institution. The section will include studies within and outside industrial arts/technology education.

What is Technology Education?

The study of technology and its importance in public education has come under great scrutinty in recent years. This, in part, has been due to the numerous educational reform reports and to the exponential advancement of technology. The concern centered around the need to produce a technologically literate citizenry. With this in mind, this section will explore what is meant by technology education and what has been its role in public education.

DeVore (1966) recommended the study of Man and Technology as the most appropriate curriculum base for industrial arts (now technology education). 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 any culture; and
5. identifies a knowledge area meeting the criterion of a discipline in the truest sense of the term (p. 2).

In order to accomplish this, DeVore recommended three technical areas: production, communication, and transportation (p. 12).

Conversely, Maley (1970) suggested that industrial arts "explore the application of technology in the solution of major social, environmental, and operational problems and face mankind" (p. 14). Maley identified a student-centered curriculum taught through the unit, group, line production, and research and development approaches.

Wright (1975) defined technology education as "the study of technology, its history, growth and future development in terms of industrial organization, materials, occupations, products, processes, and problems, including multi and interdisciplinary academic endeavors as well as laboratory experiences; for the purpose of acquainting students with the technology culture, aiding them in the discovery, development, release, and realization of their responsibility therein, and enabling them to better cope with cultural change caused by technological advancement."

The Jackson's Mill Curriculum study concluded that the primary integrating thread for technology education is the mutual interaction of the domains of knowledge and various adaptive systems. Technology, as an adaptive system, has been, and will be, fundamental to the survival of the human race. The study of technical means leads to an understanding of culture - which is transferable to future situations. The study identified three adaptive systems; the ideological, the sociological, and the technological. These adaptive systems are mutually interactive with the human-made and natural environment. Relative to a curriculum base for the study of technology they identified four categories: construction, manufacturing, communication, and transportation (Hales and Snyder, 1982).

Daiber (1979) identified ten technology education contributions to general education:

1. promotes the student's understanding of tools, materials, processes, products, and careers that are part of the technological era;
2. provides the setting to examine societal problems which result from the use of technology;
3. involves learning experiences through building projects, conducting experiments, or performing other laboratory activities in which students interact, problem-solve, acquire psychomotor and cognitive skills, and develop respect and responsibility of good citizenship;
4. increases students' knowledge about past, present, and future technological developments and the effects innovations propose to their local community;
5. stimulates an awareness of the causes and effects of technological change;
6. promotes the student's ability to place assessment on their use of technology;
7. aids students in determining what technology is appropriate for local and global usage;
8. creates an atmosphere which initiates stressful situations to help develop coping skills for survival in a technological culture;

9. helps to develop a literacy within society which will provide its members with the knowledge necessary to understand the fundamentals of technology; and
10. may serve as the nucleus of general education in which interdisciplinary activities reflecting industry, society, science, or pure technology may be performed to illustrate the relation of various roles in society, and how they are interrelated to technology (p. 42).

McCrory (1980), in looking at the content structure for technology education, identified six elements of technology universal to all technology: humans, information, energy, tools processes, and materials. Based on the six elements of technology, McCrory categorized the study of technology in three contexts: transportation, production, and communication.

The Commission on the Year 2000 investigated the key constraints for curriculum development for the study of technology. Their report empahsized the use of process and methodological organizers, instead of content organizers. Among these were problem-solving, decision-making, values, systems, and social changes (Lauda, 1983, pp.11).

Maley's work (1983) included studying the heritage of technology as part of technology education. He included an investigation of the past, present, and future of technology. Maley also suggested that this study be conducted through an anthropological approach to teaching technology.

The Principles of Technology Project (1983) organized a study of high technology in the vocational education. It is based on the concept that future technicians must know more that one energy system in order to survive and solve tomorrow's problems. This applied physics course was designed to be taught by properly inserviced science, technology, or vocational teachers. It was organized under 13 topic areas: (1) force, (2) work, (3) rate, (4) resistance, (5) energy and momentum, (6) power, (7) force transformers, (8) energy converters, (9) optical systems, (10) transducers, (11) time constants, (12) vibrations, and (13) radiation. These topics would comprise the study of mechanical systems, fluid systems, thermal systems, and electrical systems.

Daniels, Karmos, and Presley (1985) developed a pretechnical curricula, grades 7-12, based on three skills: generalizable, transition, and problem-solving. The generalizability skills include: reasoning, communication, mathematical, interpersonal, attitudinal, and technical. Transition skills comprise: change in environment, change in relationships, change in self, stress, loss, grief, and decision making. Problem-solving skills encompass cooperative group skills, interpersonal skills, information-related skills, task-related skills, and understanding human behavior. The content in grades 7-10 is generalizable skills, transition skills, and problem-solving skills. The content in grades 11-12 consist of generalizable skills, transition skills, problem-solving skills, entry-level job skills, and high tech skills (the emphasis will be on simulations) (p. 37).

Maley (1985) outlined guidelines for achieving excellence in industrial arts (technology programs). He recommended an integration of mathematics, science, social studies, art, and technology; therefore, promoting a holistic form of education. The programs provide for student involvement through a wellspring of experiences. Among these were problem-solving, inquiry, research, and design (pp. 12-13).

The 1985 Mississippi Valley Conference discussed the topic of technology education and its relationship and implications for the industrial arts/technology education profession. Tuttle presented a paper examining the issue "Does Research Support the Three Cluster Areas: Communication; Production; Transportation? or The Four Cluster Areas: Communication; Production; Construction; Transportation?" He noted that there was not a true consensus relative to whether the three cluster concept or the four cluster concept was more universally accepted by the profession for the study of technology education (Tuttle, 1985). At the same conference, Forkner presented a view on how to "marry" traditional materials with the systems approach to technology education. He stated:

> Marrying the traditional materials program of industrial arts to the development of systems areas of technologies will likely involve a whole generation of newly designed, suitable projects from which students may learn as they study technologies in our classrooms/laboratories. The program must be designed to lure "shop" teachers into the field. One which will interest them

> in providing their students a genuine study of technologies - not just in "building projects" (pp. 5-6).

Squier criticized skill development as the primary goal of technology education.

> A time of prioritizing is upon us. We must select from a nice to know content vs. a need to know content. The focus should be upon the development of an understanding of technology as our priority and abandonment of project-skill development hang-up....that technology education should not focus upon technical content....The real focus, however, must be upon knowledge, skills, and attitudes essential for all students to live and interact in the artificial, humanmade world (Squier, 1985, pp. 5, 6, and 7).

In his paper, Squier called for a general education approach to technology education. He provided a scenario for technology education in the year 2001 that outlined the purpose of elementary school technology education as developing values, attitudes, and knowledge regarding the social, economic, political, environment and career issues of the future through problem-solving and creative thinking activities. At the middle school hands-on learning experiences should be provided through the systems of communication, production, and energy/power/transportation. It should include activities in research and development, materials and processes, industrial communications, machine controls, safety, the history of technology, servicing of goods, and aesthetics. At the high school level, technology education should include energy/power, transportation, communication, construction, CAD, and CAM (pp. 15-16).

Martin (1985) noted that "the nature of general instruction in technology in the public schools must focus on the development of technological literacy" (p. 37). Technology education must be concerned with societal needs by providing a technical base to understanding the social, political, and economic impacts of these issues (p. 39).

At the 1985 American Vocational Association Conference, Maley outlined principles for implementing a technology education program:

1. technology education is a vital educational component in a highly technological society;

2. present and future societies will depend upon the wise use of, as well as wise decisions about, technology as an important factor in survival and human progress;
3. technology education must be packaged and delivered in keeping with the characteristics and needs of *all* students at all ability levels;
4. technology education must be an experimentally based (laboratory hands-on) program that utilizes the best of research findings in how the individual learns;
5. technology education must be taught in the context of a multi-disciplinary and cross-disciplinary involvement of the learner if understanding as well as functional literacy with technological issues or concepts are to be accomplished;
6. there must be a broadened perspective about the nature of technology education that would extend it beyond the craft domination of previous years and most programs and this would also imply that technology education would be much more broadly conceived than what one would call technical education;.
7. Technology education must be conceived and implemented in a holisti process that recognizes the fact that nothing can be studied to any measurable degree within a single discipline; and
8. as a final principle in this listing, I would persist in reminding the profession that the overriding goal of our educational system is the development of people -- the fulfillment of people, and the achievement of the promise in each (pp. 2, 3, 4, and 5).

Glines (1986) identified four key categories of concern for technology education to continue to meet the needs of tomorrow's youth:

1. the potential global and societal futures which will affect all of human-kind;
2. the implications of these futures for education--the effect of the 64 global dilemmas or possibilities-crises or opportunities-upon schooling and learning;
3. the practical action steps which technology education should and could take now and in the next five years to begin to better address the potential alternative futures; and

4. the educational and societal data, the supporting resources, and the classroom materials which are available to assist the staffs, students, and communities through a period of transition (p. 7).

In calling for a reform in science education, Hurd (1986) noted the importance of the study of technology as an important component of science education. Miller (1986) outlined concepts and measures of technological literacy. As part of these concepts and measures were a blending of science and technology to develop scientific and technological literacy.

Hughes, in testifying before a hearning for the House Committee on Elementary, Secondary, and Adult Education of the United States Congress emphasized that technology education helps teach one how to manage technology through experiences in applying technology. Hughes went on to say that technology education programs foster technological literacy teaching the historical role of technology in human development, the relationship between technological decisions and human values, the benefits and risks of choosing technology, the changes occurring in current technology, and an understanding of technology assessment as a method for influencing the choice of future technologies (Hughes, 1986, p. 8).

At the same hearing, Rockefeller emphasized the importance of the study of technology to catch up and keep pace with the educational systems of Japan and several European nations. Technology education provides the technical skills for youth to compete in the 21st century (Rockfeller, February 19, 1986). DeVore and Brummett similarly agreed with Hughes and Rockfeller with their testimony.

Boyer (1983) called for all children to study technology and should be required for all students (p. 304). He included the study of technology as one of the twelve core areas of the curriculum.

The International Technology Education Association (1986) defined technology education as "a comprehensive, action-based educational program concerned with technical means, their evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their social/cultural impact" (p. 25).

From this definition, the ITEA identified the goal of elementary technology education as learning reinforcement and technological awareness. The goal of middle school technology education is orientation and exploration. Finally, the goal of high school technolog education is preparation in technology (p. 25).

In the same document, the ITEA identified ten student benefits of technology education. They are:

1. know and appreciate the importance of technology;
2. apply tools, materials, processes, and technical concepts safely and efficiently;
3. uncover and develop individual talents;
4. apply problem-solving techniques;
5. apply creative abilities;
6. deal with forces that influence the future;
7. adjust to the changing environment;
8. become a wiser consumer; and
9. make informed career choices (p. 25).

The ITEA also defined criteria for a technology education program. At all levels, the program/course content is based on:

1. an organized set of concepts, processes, and systems that are uniquely technological;
2. fundamental knowledge about the development of technology and its effect on people, the environment, and culture;
3. Instructional content drawn from one or more of the following areas:
    a. communication - efficiently using resources to transfer information to extend human potential,

b. construction - efficiently using resources to build structures or constructed works on a site,

c. manufacturing - efficiently using resources to extract and convert raw/recycled materials into industrial and consumer goods,

d. transportation - efficiently using resources to obtain time and place utility and to attain and maintain direct physical contact and exchange among individuals and societal units through the movement of materials/goods and people;

4. assisting students in developing insight, understanding, and application of technological concepts, processes, and systems;
5. applying tools, materials, machines, processes, and technical concepts safely and efficiently;
6. developing student skills, creative abilities, positive self-concepts, and individual potentials in technology;
7. developing student problem-solving and decision-making abilities involving human and material resources, processes, and technological systems;
8. preparing students for lifelong learning in a technological society.
9. activity-oriented laboratory instruction with students reinforcing abstract concepts and concrete experiences; and
10. a combined emphasis on "know-how" and "ability to do" in carrying out technological work (pp. 25-26).

Peterson (1986) identified the key characteristics for elementary technology education:

1. relates in a functional way information taught in all areas;
2. utilizes the children's natural interests in activity, an in manipulating materials and devices as a means for expressing themselves;
3. ties the curriculum together - provides a unifying core for the curriculum;
4. proceeds from specific/concrete to general/abstract activities.
5. Contributes to the development of potential and abilities present within the elementary grade students;
6. reflects the needs and interests of the students and develops basic competencies for living in a technological environment;
7. integrates, unifies, and reinforces existing curricular concepts through the technological component of our culture;
8. can be implemented through existing elementary classroom teachers or a specialist;
9. applications oriented curriculum with specific learning experience lesson plans developed to compliment the following areas:

   Social Studies

   Science

   Math

   English-Reading, Spelling

   Music

   Physical Education

   Arts

   Learning Disabilities

   Multiple Handicapped

   Interdisciplinary Studies--Team Teaching;
10. has particular value in the integration of communication resources into the school environment;

11. provides an additional avenue for student excellence and success. and provides natural feedback for self-evaluation; and
12. problem oriented learning motivates students to pursue learning independently (p. 49).

Peterson also outlined the basic themes and activities for elementary school technology education. Kindergarten is concerned with the technology we see and use every day. Grade 1 deals with technology in our home. Grade 2 emphasizes technology in our community. Grade 3 teaches technology in our world. Grade 4 is concerned with technology and history. Grade 5 concentrates on technological and natural systems. Grade 6 emphasizes how technological systems and devices work (p. 55).

Bame (1986) described the middle school technology education curriculum as exploratory in nature, broad and fundamental, interdisciplinary, and vertically integrated (p. 73). To Bame, technology is an interaction between the faces, interfaces and counterfaces of technology. The areas of study at the middle school level identified by Bame are: (1) processing, (2) energy and power, (3) manufacturing, (4) construction, (5) communication, (6) transportation, and (7) automation (p. 80).

Diaber and LaClair (1986) organized the study of high school technology education around the four systems: (1) communication, (2) construction, (3) manufacturing, (4) transportation (p. 95). Grade 9 is the awareness level, grade 10 is the skill development level, grade 11 is the realization level, and grade 12 is the investigation level. At grade 9, they recommend an introduction to technology course. Three courses are recommended at grade 10: communication technology, material and process technology, and transportation technology. Communication systems, construction systems, manufacturing systems, and transportation systems are emphasized at grade 11. Grade 12 is comprised of advanced communication technology that includes fiber optics, telecommunications, satellite, etc.; advanced construction technology that is made up of laser beams, foam homes, space colonies, etc.; advanced manufacturing technology that encompasses cybernetics, robotics, space factories, etc.; and advanced transportation technology that includes rapid transit, hovercraft, space shuttles, etc. (p. 120).

The International Technology Education Association (n.d.) stated the following as the professional belief that technology education:

Should be a part of the learning experience of all students at all levels of grade and ability, in order that they may understand, function, and control their industrial/technological environment.

Requires the highest level of competence from its instructional staff. Teachers must possess creativity and ingenuity, enjoy working with people, and maintain a high degree of personal and professional integrity.

Uniquely contributes to students of all learning ability levels of both sexes and regardless of career choices. It provides equal opportunities for those of high or low economic status, and those who may choose a professional life or a future as an industrial workers. It's equally important to everyone as all members of society must learn to aware of and learn effectively in tomorrow's technological society.

Fosters an awareness of industry and enterprise and their place in the world culture. It also provides opportunities for learners to discover their talents and abilities in the areas of technology and applied science in the world of industry.

Activities form a continuum with other visual and applied arts, ranging from the free expressive forms to the more exacting demands of machine tools and applied sciences.

Is an organization of subject matter which provides opportunities for experiences concerned with developing insights into technology, its evolution, utilization, and significance, and industry, its organization, personnel, systems, techniques, and products; and their social/cultural impact.

Provides technical skills and knowledge basic to most occupations and professions. Technology Education enables the future scientist and engineer to solve technical problems, and the future craftsperson or technician to develop knowledge, skills and ability to obtain technical information.

Provides wholesome changes in learners. These may take the form of a developed interest in the human-made world - its materials, products, and processes. These changes may also involve self-evaluation of attitudes towards constructive work and how this work can be utilized for health and recreation, as well as economic value; they may involve the development of a favorable attitude toward creative thinking, and toward character improvement - knowing and making the most of one's environment.

Employs actual involvement of tools, machines and materials, which reinforces the written and spoken word. It enables all students to derive meaning from concrete experiences which aid in the understanding of abstract ideas and the development of concepts.

In conclusion, technology education has been associated both as part of general education and vocational education. The study of technology, on the one hand has been based on the study of content: construction, manufacturing, communication, and transportation. Conversely, it has been structured around processes and methods. Among these are problem solving, inquiry, decision making, and designing. Technology education has also emphasized the study of social, cultural, and environmental problems that face mankind. Finally, it has been concerned with the solution to the technological problems of tomorrow.

DeVore, McCrory, and Tuttle support the notion that the study of technology should be organized as transportation, production, and communication. The Jackson's Mill Curriculum Study also agrees with this organizational structure. On the other hand, Maley, Daniels, Karmos, Presley, and Squier view the organization for the study of technology as processes and concepts. They recommend such organizers as research and development, problem solving, group process, unit process, and systems. Both groups contend that their organizational structure is designed for pre-technical and general education.

To implement the study of technology, the focus at the elementary level should be learning reinforcement and technological awareness. At the middle school level, the focus should be orientation and exploration. The focus at the high school level should be preparation in technology. This implementation should provide opportunities for students to develop individual talents, apply problem solving techniques and creative abilities, and adjust to the changing environment.

From this review of what technology education is, it is necessary to examine a historical perspective of curriculum organization outside and within the industrial arts/technology education discipline. This will provide the basis and foundation for the traditional and industrial view of technology education previously presented.

A Historical Perspective of Curricular Organizers Outside Industrial Arts/Technology Education

With the successful launch of Sputnik I in 1957 came a major concern for educational reform in the United States. As a result, numerous educational projects were developed, tested, and implemented, in some degree, to combat this evolution in technology. This section will concentrate on curricular organization that resulted from this technology explosion. Representative curriculum projects and their organization will be presented to depict the school curriculum exclusive of industrial arts/technology education.

The University of Illinois Committee on School Mathematics (UICSM) (1960) was organized at the University of Illinois and it was supported by the United States Office of Education and the National Science Foundation. The purpose of the project was to allow students to discover mathematics through problem solving experiences. The project was organized around a four-year sequence of 11 units; (1) the arithmetic of real numbers; (2) pronumerals, generalizations, and alegebric manipulations; (3) equations and inequations, applications (4) ordered pairs and graphs; (5) relations and functions; (6) geometry; (7) mathematical indiction; (8) sequence; (9) exponential and logarithmic functions; (10) circular functions and trigonometry; (11) polynomial functions and complex numbers (Goodlad, 1964, pp. 14-15).

The School Mathematics Study Group (SMSG) viewed mathematics through concepts and their relationships, the structure of mathematics as being central to the study of mathematics. Grade 7 and 8 included abstract concepts, the role of definitions, the development of precise vocabulary and thought, experimentation, and mathematical truth. Concepts in grades 9 and 10 emphasized number systems as a progressing development, metric and non-metric relationships in geometry, and introduced students to measurement and elementary statistics. Grade 11 included trigonometry, vectors, logarithms, mathematical induction, and complex numbers. Grade 12 introduced students to polynomials, exponential, logarithmic, and trigonemetric functions, and matrix algebra that emphasized practical applications (Goodlad, 1964, pp. 16-17).

Another project, the University of Maryland Mathematic Project (UMMAP), was developed for grades 7 and 8. Grade 7 emphasized systems of numeration, symbols, properties of natural numbers, factors and primers, the number one and zero, mathematical systems, points, lines, curves, and planes, graphs on a plane, proofs and equations in the system of real numbers, estimates and approximations, and averages. Grade 8 included concepts in the systems of rational numbers, logic and number sentences, equations, a system of number phrases, factoring and products in the system of number phrases, fractional number phrases, the system of real numbers, the logic of number sentences, the system of integers under addition, plane figures, and scientific notation for arithematic numbers (Goodlad, 1964, pp. 19-20).

The University of Illinois Arithmetic Project emphasized teaching mathematics through the study of patterns, relationships, forms, and structure in systems of numbers, geometrical figures, functions, and other objects of interest. Topic areas included maneuvers on lattices and number lines, functions, and fundamental topics (Hohn, March, 1961, p. 102).

The Physical Science Study Curriculum (PSSC) was concerned with "the basic structure of physics, the acquisition of new physical knowledge, and the necessity for understanding rather than memorizing basic concepts" (Goodlad, 1964, p. 24). PSSC was divided into four phases. The first phase dealt with the concepts of time, space, and matter. Phase two emphasized the study of light. The study of motion comprised phase three. The fourth phase studied electricity and the physics of the atom (Goodlad, 1964, p. 24).

The Biological Sciences Curriculum Study (BSCS) provided three versions of the curriculum, around nine key concepts: "changes of living things through time (evolution); diversity of type and unity of patterns of living things, genetic continuity of life; biological roots of behavior; complementarity of organisms and environment; complementarity of structure and functions; regulation and homostatis - the maintenance of life of change; sciences as inquiry; intellectual history of biological concepts" (Goodlad, 1964, pp. 26-27). The Green version covered the biosphere disected; patterns in the biosphere; the individual disected; evolution, behavior, and man. The Yellow version topics were in cellular biology. The final version, Blue, covered topics in molecular biology and its contributions to the general understanding of the universe (Goodlad, 1964, p. 27).

The Chemical Bond Approach Project (CBA) introduced students to chemistry, instead of a series of chemical reactions and laboratory techniques (Strong, March, 1961, p. 126). Another chemistry project, Chemical Education Materials Study (Chem Study) looked at the study of chemistry through a high emphasis on laboratory experimentation (Goodlad, 1964, p. 33).

The social studies curriculum produced two key projects: the High-School Geography Project and the Anthropology Curriculum Study Project. The High-School Geography Project was organized around five objectives: "(1) respect for objective methods of investigation, heightened awareness of spatial factors and elements of the natural environment, and reinforced appreciation of the world-wide interdependence of societies, (2) understanding of the ideas involved in mapping, regionalizing, analyzing man-land relations, and in interpretation of spatial relations, (3) knowledge of major world patterns, and knowledge of specific place locations of geographic information; and (5) ability to read and interpret maps, to handle a geographic vocabulary, and to participate creatively in the geographic enterprise" (Pattison, November, 1962, p. 368).

The Anthropology Curriculum Study Project was developed to teach basic concepts, methods, and structure of anthropology (American Anthropological Association, November, 1962, p. 2).

Zoller (1973) developed the Technology for Social Action Curriculum (TSAC). TSAC was designed for the non-science student, emphasizing a "technologically and humanistically integrated decision-making curriculum" (p. 5). Zoller listed 25 possible topics or modules of organization for the curriculum:

1. food and nutrition;
2. public health and medical technology;

3. you and the environment;
4. urbanization, industrialization, and overcrowding in modern society;
5. interrealtionship among people and modern communication;
6. energy and society - Quo Vadis;
7. society of the future;
8. genetics, heredity and environment;
9. modern technological society and "do it yourself";
10. learning and human development;
11. natural resources and their intelligent use;
12. cybernetics and automation;
13. welfare, crime and warfare in modern society;
14. biological engineering and drugs;
15. work and leisure in modern societies;
16. technology, development and national security;
17. religion, tradition and science;
18. population, biology and population dynamics;
19. science, technology and politics;
20. modern economics;
21. evaluation and revolution in nature and society;
22. the cycle of life - what is life;
23. the nature of science, engineering and technology;
24. individual and society; values, self-interests and decisions; and
25. "future shock" and alternative futures (pp. 106-107).

The Man-Made World course was developed by the Engineering Concepts Curriculum Project for the average student not interested in pursuing a science or engineering career. The course emphasized two key goals: (1) to design learning so that the disadvantaged and unmotivated can succeed and (2) to develop a technological literate citizen. The course was organized around eight mini-courses. (1) Technology<-->People, (2) Human User<-->Technology<-->Job, (3) Technology<-->Society, (4) Technology<-->Environment, (5) Quality of Life, (6) Man as a Consumer, (7) Communication Man<-->Man<-->Machine<-->Machine, (8) Thinking Machines (Liao et al, January, 1975).

Project CREATION (Concern Regarding the Environment and Technology in our Nation/Neighborhood) (1978) was an interdisciplinary science and social studies curriculum to teach environmental education. The curriculum was divided into four categories: pollution, energy, land use, and urban management. Barnet (1978) called for a humanistic curriculum and synthesized technology with humanistic awareness. The curriculum outlined by Barnet was a multidisciplinary, problem-centered approach to education.

The Future Studies Program of the School of Education at the University of Massachusetts in 1979 developed a curriculum to integrate future studies into the elementary and secondary curriculum. Its organization consisted of synergetic approach to education, with topics in forecasting methods, computer-based instruction, energy usage and conservation, planning, and technological literacy. Another futuristic study, Curriculum 2000, was outlined by Buchen (1980) clustered under three headings: frameworks, methodologies, and values.

The Biological Sciences Curriculum Study (1981) designed nine curriculum resource units called Innovations: The Social Consequences of Science and Technology (IST). IST was organized under the categories of science, technology, and society; television; low-head hydropower; day care; energy-technologies; dilemmas and options; human reproduction; computers and privacy; biomedical technology; and food technology.

Another project by the Biological Sciences Curriculum Study, Science, Technology, and Society (1983), was a result of President Carter's message on science and technology delivered to the United States Congress in March of 1979 (Foreword). The project was a interdisciplinary approach to teaching social, technological innovations, and their social consequences. The one semester program was organized under five categories: (1) the nature of science, (2) the nature of technology, (3) the nature of society, (4) the relationship between science and technology, and (5) the relationship between society and technology.

The Conference on Goals for Science and Technology Education Grades K-12 (1983) recommended that all students, K-12, study science and technology almost daily. They recommended a curriculum that would provide hands-on experiences that focused on the relationships between humans and the total environment. They emphasized problem solving as the main approach for the curriculum.

Gomez (1985) outlined a computer science curriculum for the secondary school level. The curriculum was organized under concepts of the computer, programming methods, problems, programming language, and application.

In summary, following the successful launching of Sputnik I, the study of technology was infused into many curriculum efforts. Among these were the areas of science, mathematics, and social studies. For the most part, these curriculums focused their organizational structure on content, processes, and concepts. Some curriculums have also been organized around the relationships between science, technology, and society.

The UICSM project allowed students to discover mathematics through problem solving experiences. The SMSG project emphasized mathematic concepts and their relationships. The UMMA project focused on mathematical systems. In science, the PSSC, BSCS, and CBA projects focused on scientific concepts, systems, and processes.

Zoller designed a non-science curriculum, TSAC, that emphasized a technologically and humanistically integrated decision-making curriculum. A similar approach was taken in the Engineering Concepts Curriculum Project and Project CREATION.

These curriculum projects set the foundation for a technology-based curriculum at the secondary school level. From this examination, it is now crucial to investigate how the industrial arts/technology education curriculum has been organized for the study of technology.

Historical Perspective of Curricular Organizers Within Industrial Arts/Technology Education

Although Bigelow (1831) identified the elements of technology that provided the basis for the study of technology, Warner is considered, by most, the first to provide the rationale and structure for the study of technology as we know it today. Warner (1947) categorized the study of technology into six divisions: (1) communications, (2) construction, (3) power, (4) transportation, (5) manufacturing and (6) management.

Wilber (1948) developed a conceptual framework for industrial arts in the context of general education. He identified three major objectives of general education and then related industrial arts to them. The first objective, transmitting a way of life, was implied to industrial through two organizers: democratic and industrial. Problem situations and training in thinking on one level organized the second objective, improving the emergent culture. The third objective, meeting individual needs, was related to industrial arts through the organizers of psychology, sociology, and biology (p. 46).

Olson, a student of Warner, expanded Warner's work in the study of technology. He noted six functions of industrial arts: (1) technical, (2) consumer, (3) occupational, (4) cultural, (5) recreational, and (6) social (p. 165). From these functions, Olson organized industrial arts subject matter for the public school. In the elementary school, the primary grades were concerned with technology and the community; and the upper grades dealt with technology and the world. The junior high school studied the manufacturing industries. In grade 7, students studied graphic arts, paper, leather, and textiles industries. Grade 8 exposed students to the ceramic, plastics, rubber, chemical, and foods industries. The metals, woods, tools, and machine industries were studied in grade 9. In the senior high school, industrial arts was comprised of power and transportation industries, electrical and electronic industries, construction industries, industrial organization and management, and research and development (p. 276). Olson (1973) further outlined his organizational structure in *Technol-o-gee*. This publication outlined three complexes of the study of technology for industrial arts: the technical, the human, and the culture.

The American Vocational Association publication, *A Guide to Improving Instruction in Industrial Arts*, outlined the curriculum as industry and civilization, the industrial organization, research and development, planning for production and manufacturing operations, production or manufacturing, distribution, and servicing industrial products.

The 1960's produced a variety of curriculum efforts in the industrial arts area. This was due to the increased emphasis on technology due to the 1957 launch of Sputnik I. Because of this, The National Defense Education Act supported curriculum development efforts to meet the technological challenges of the future. The curriculum projects can be classified into the following headings: integrated programs, interpreting industry projects, occupational or career programs, or technology based projects.

The Richmond Plan (1961) was an integrated pre-engineering curriculum designed to cross-discipline English, science, and mathematics and technical laboratory work. The Partnership Vocational Education Project (1965) was a similar interdisciplinary project for grades 11 and 12. Another integrated project, Introduction to Vocations (1963), emphasized the study of occupations in an exploratory nature.

The American Industry Project (1968) was a contemporary approach to interpretating industry. The conceptual framework for the project was organized around the following topics: communication, transportation, finance, property, research, procurement, relationships, marketing, management, production, materials, processes, and energy (p. 4). The Functions of Industry organized the study of industry into four functions: (1) research, (2) development, (3) planning for manufacturing or producing a product(s), and (4) manufacturing (Bateson and Stern, pp. 7 and 20).

The Georgia Plan (1964) divided the study of industrial arts into two parts: prevocational and college preparatory. In the prevocational sequence, grades 7-9 studied general industrial arts. The subject areas were: industrial organization and management, product planning, design, drafting, woods, metals, electricity, mechanics, graphic arts, and production processes. Grade 10 emphasized general area courses that included drafting, woods, metals, electronics, mechanics, and graphic arts. The prevocational grades 11 and 12 program provided two options: unit courses or part-time co-op work experience. In the college preparatory sequence, grades 7-9 studied transportation, manufacturing, and communication. Grade 10 emphasized American Industries. Engineering Drafting and Descriptive Geometry was the focus of grade 11. Grade 12 was a research and development course (Hackett, pp. 25-28).

The Galaxy Plan (1965) was a career orientation program, designed around four clusters: (1) materials and processes, (2) visual communications, (3) energy and propulsion, and (4) personal services. The program was designed as middle school exploratory program (1965, pp. 25-27). The Careers and You Project was another career education project. It was designed around three basic themes: (1) personality characteristics, (2) occupational styles/work environment, and (3) career clusters (Dugger et al., 1975, p. 62).

The Alberta Plan was a technology based curriculum. The program was divided into four phases. Phase I was a seventh grade course organized into the study of materials, processes, machines, and tools. Phase II, an eighth and ninth grade program, concentrated on the study of computer technology, power technology, graphic communications, testing technology, mechanical technology, electronic technology, and power technology. Phase III, a tenth grade course, included the topics of authority, decision making, communication, and organization. Phase IV, an eleventh and twelfth grade program consisted of the study of power, power transmission, mechanical technology, computer technology, electronics, electricity, materials, graphic communications, and testing technology (Ziel, 1966, pp. 8-9).

The Maryland Plan, designed by Donald Maley (1973) of the University of Maryland at College Park, was a student-centered study of technology at the middle school level. The seventh grade course concentrated on a until study of man's technological developments. In the eighth grade students studied technology through the group project and line production. The ninth grade consisted of research and experimentation activities.

The Industrial Arts Curriculum Project (1966) was an industrial technology approach to the study of technology. The project organized the study of industrial technology into two broad categories: manufacturing and construction. Manufacturing was concerned with producing products in a plant and distributing them, while construction dealt with building structures on a site. Both middle school courses emphasized industrial management technology, industrial personnel technology, and industrial production technology.

The Ballard and Williamson Study (Texas Plan) organized a self-management study of technology. Grades K-5 provided an integrated approach to an orientation to the technological world. The middle school conceptual framework was build around venturing in the technological world. The high school courses were based on concentrating in the technological world through the study of production transportation technology, and communication technology (February 20, 1975).

Orlando (1972) examined the study of technology in the area of manufacturing through concept-statements for curriculum development. His study was organized under systems of manufacturing: household (pure), handicraft-use, handicraft-retail, handicraft-wholesale, factory-basic, factory-mass production, and factory-automation (pp. 48-109).

Another study, *Technology A Process Approach* by Halfin, outlined the study of technology into 17 processes through a Delphi approach. The processes included: (1) defining the problem or opportunity operationally, (2) observing, (3) analyzing, (4) visualizing, (5) computing, (6) communicating, (7) measuring, (8) predicting, (9) questioning and hypothesizing, (10) interpreting data, (11) constructing models and prototypes, (12) experimenting, (13) testing, (14) designing, (15) modeling, (16) creating, and (17) managing (pp. 144-204).

In researching a theoretical base for the study of technology, Kasprzyk (1973) concluded engineering to be the source of subject matter (p. 142). He related construction to civil engineering, production of raw materials to mining and agricultural engineering, processing raw materials to metalurgical and chemical engineering, and manufacturing, transportation and communication to mechanical and electrical engineering (p. 145).

The Jackson's Mill Curriculum Study provide the knowledge base for the study of technology, identifying four categories of study: communication, transportation, manufacturing, and construction (Hales and Snyder, 1982). From this document, the Technical Foundation of

America study, *Industry & Technology Education* (1984), developed content and structure for the four content organizers of the Jackson's Mill Project.

In recent years many states have developed technology based curriculum to replace traditional industrial arts. This is due in part to the numerous educational reform reports. But at the same time, technology educators understood that the industrial technology and the "craft" approach to industrial arts were too narrow in scope and outdated to continue to prepare a technologically citizenry.

The New York Futuring Project was a cooperative effort of agriculture, business education, distributive education, home economics, health, industrial arts, technical mathematics, and trades and industries. At the middle school one unit of technology education is required at the completion of the eighth grade. The course included, but is not limited to biotechnology, information communications, and physical technology. All senior high school students must take "Introduction to Occupations." This is a 1/2 unit course that emphasizes the working citizen personal resource management.

For technology education, students must complete two one semester systems courses. The systems courses include communication, production, and transportation. Students are also required to take three foundation courses that are one semester in length. The foundation courses include technical drawing, energy, and electronics. Students must take one additional elective to complete the three-unit sequence. To complete the five-unit sequence, students can choose additional electives or take any of the systems or foundation courses adding up to two additional credits.

Elective options in communication include: computer applications, computer graphics, electronics/audio, electronic/communications, electronics/digital, and graphic communications. Production elective options include: architectural drawing, computer-aided design, computer-aided manufacturing, production (research and development), production (structures), and materials processing. The transportation options include: aerospace, energy applications, and transportation (land) (pp. 10-11).

The Illinois Plan (1984) organized the study of technology under four broad headings: transportation technology, energy utilization technology, communication technology, and production technology. Elementary school technology is technology studies units geared to becoming aware of technology. The middle school emphasizes exploring industry and its technologies. The high school study of technology is divided into two phases; grades 9 and 10 include a study of industrial technologies, with grades 11 and 12 concentrating on advanced technical studies and vocational programs.

The Systems of Technology Curriculum Project revised the Texas industrial arts curriculum into three systems: production, visual communication, and energy at the seventh and eighth grade levels. The proposed high school curriculum is organized under the same three systems with an introduction to technology course at the ninth grade and grades 10-12 studying advanced technological systems.

The International Technology Education Association (1986) recommended th following curriculum organization for the study of technology.

1. Grades 6-7 Introduction to Industrial and Technological Systems
2. Grades 8-9 Communication Systems
   Construction Systems
   Manufacturing Systems
   Transportation systems
3. Grades 9-12 Communication:
   Graphic Communications Systems
   Electronic Communications Systems
   Media Communications Systems
   Construction:
   Construction Planning and Design
   Constructing & Servicing Structures
   Electro/Mechanical Systems & Servicing
   Manufacturing:

Manufacturing Materials & Processes

Designing Products for Manufacture

Manufacturing Production Systems

Transportation:

Technical Elements Transportation

Planning & Designing Transportation

Human & Goods Transportation Systems

(pp. 26-27).

In conclusion, the elements of technology were first organized for the mechanical and industrial arts by Bigelow. However, Warner's organizational structure has been most widely accepted by the industrial arts/technology education profession. This industrial emphasis has also been supported by Wilber, Olson, and in recent years by DeVore, McCrory, the Jackson's Mill Curriculum Study and the TFA study. Others, like Maley, have contended that the curriculum should be student-centered, emphasizing process and problem solving.

Like many other curriculum areas, the successful launching of Sputnik I generated many innovative technology curriculum projects. Among these were the Richmond Plan, the Alberta Plan, IACP, and the Galaxy Plan. All these projects emphasized an industrial approach to the study of industrial arts and technology that reflected Warner's thinking.

In the last several years, educational reform movements have caused many states to re-examine their industrial arts curriculum and change it to a technology curriculum. Among these states are New York, Illinois, and Texas. All these curriculums emphasize a systems approach to the study of technology.

From this historical perspective of curricular organizers within industrial arts/technology education, it is important to examine an international perspective of how technology education curriculum has been organized.

International Technology Education Curricular Organizers

> International education cannot be the work of one country. It is the responsibility and promise of all nations. It calls for free exchange and full collaboration. We expect to receive as much as we give, to learn as well as to teach (Speakman, 1966).

This section will present an examination of curricular organizers within technology education from an international perspective. Selected countries will be highlighted so that a basic understanding as to how the study of technology is organized on a global basis. It should be noted that the highest percentage of countries viewed technology eduaction as a part of general education instead of vocational eduaction.

Loyd (1976) outlined a rationale for international technology education at the American Industrial Arts Conference in Des Moines. He stated:

> Technology is of an international scale and should be expressive of the needs of all the people from all nations. One of the biggest problems with technology is the way some nations claim sole proprietorship of "their" technology and express an unwillingness to share. If anything is vitally important to the survival of humankind, it is a united effort to use and control technology efficiently. We must work together for the betterment of but one king, humankind...An international cooperative system of education would facilitate this technological exchange (p. 279).

The International Congress on Science and Technology reported the need for UNESCO nations to work cooperatively to extend and improve science and technology education. The Congress concluded that there must be a linkage between technology education and science education, but distinction must be made in terminology between 'education' and 'training', as well as between 'general' and 'vocational or technical' education.

> In the current interaction between synthetic tendencies in education, which seek the unification of basic concepts, and the analytical tendencies of evolving towards further specialization, the integration of knowledge and skills, as well as attitudes and values contributes to the development of a concept of technology education, which is broad-based and relevant to national socio-economic development needs. In such a concept, the total process of education, as its fundamental objective, aims at enabling the student to understand his three-fold environment

of nature, society and man-made systems in an indivisible combination of science, that deals with technology education, that provides an introduction to man's application of his scientific discoveries and inventions in the solution of problems he encounters in his progress (1981, p. 22).

The Congress also stated that technology education should be an integral part of all children's education at all levels. "Hence technology education is a *sine quo non*, both to understand the scientific basis of techniques and devices, and also to acquire the requisite skills for productive work and efficient living in different societies" (1981, p. 23).

In the 1983 UNESCO report, *Technology Education as part of General Education*, the findings showed that of the 37 countries surveyed, the most frequent response was technology education as a part of general education, not vocational education. In the report, Dr. Simon R. Nkonoki of Tanzania stated "that technology education is an integral part of general education and is imparted to pupils and adults for the purpose of improving their lives, irrespective of whether or not it leads to paid employment (p. 6)." The report went on to state that "technical subjects are generally becoming separated from practical vocational training and are focusing on understanding and application because schools are generally realizing that technical subject can make a significant contribution to a pupil's general education (p. 4)." The report also stated that the study of technology must use a "learn by doing" method. Finally, the report stated that most developing countries were not trying to limit the study of technology to one course, but develop a new pedagogy that would integrate the acquisition of knowledge from practical skills to moral and civic education.

Deforge (1972) outlined three purposes for the study of technology that bridges across countries:

1. to facilitate observation of the students, either individually or in teams faced with a specific problem requiring them to dismantle, reassemble and to create objects of their own design;

2. to promote guidance, particularly towards technical and scientific education, by arousing positive motivation; and
3. to give boys and girls the tools to understand the environment in which they live; and introduction to technology, interpreting the diagrams, methodology, and the organization and sociology of work (p. 2).

The Committee for General and Technical Education report, *The Teaching of Technology* (1972), identified four trends in the purpose of teaching technology and four trends in forms of teaching technology. The trends in the purpose of teaching technology were:

1. *technology and social education*: the polytechnic approach;
2. *technology and people*: group work;
3. *technology and interdisciplinary*: the project method; and
4. *technology and disciplinary*: the analytical methods (Deforge, 1972, p. 3).

The report identified the following forms of teaching for technology education:

1. technology as a guiding theme;
2. technology as an end in itself;
3. technology as a subject in its own right; and
4. technology as a form of motivation (Deforge, 1972, p. 4).

From this foundation information relative to international technology education, it is important to examine specific countries to gain a better understanding of the true international perspective of technology education.

United Kingdom

Traditionally, the legal responsibility of the curriculum has rested with the local or institutional level in the United Kingdom. However, the present governmental administration has set curriculum guidelines and financial support for improving the quality of education. To that end, a new effort the Technical and Vocational Education Initiative, was established in 1982 upon the request of the Prime Minister through the Manpower Services Commission. Other technology curriculum efforts are ongoing by the National Centre for School Technology at Trent Polytechnic and the British School of Technology.

Among the courses included in the Technical and Vocational Education Initiative are:

1. bio-technology;
2. technology;
3. electronics;
4. engineering;
5. computer studies;
6. information technology;
7. graphics;
8. design;
9. media studies;
10. construction industries; and
11. craft design and technology (pp. 7-13).

The Schools Council Project Technology defined technology as "Technology is the purposeful use of man's knowledge of materials, sources of energy and natural phenomena" (p. 16). The course, Craft, Design and Technology is divided into eight curricular organizers: (1) awareness, (2) middle years, (3) other secondary (4) design-based, (5) applied/engineering science, (6) electronics, (7) control technology, and (8) modular. At the awareness level students learning about technological change and its implications on society. The middle years course is designed for ages eight to thirteen. Its emphasis is on students solving simple mechanical problems. The other secondary courses are classified as those course not falling in one of the categories, but that have a technological nature.

The design-based courses are geared to develop the student's ability to design. Emphasis is placed on creative thinking and problem-solving. The applied science and engineering science and design courses are subdivided into the following headings: (1) automotive engineering, (2) mechanical engineering, (3) materials technology (metals, polymers, and concretes), (4) applied science, (5) experimental science, (6) control technology, and (8) agricultural engineering. The electronic course, for the most part, places more emphasis on practice than on theory. Examples of projects are:

1. measurement of speed of sound;
2. monitoring the effect of noise on human reaction time;
3. design of an electronic lock, with alarm system; and
4. design and manufacture of an electrocardiograph.

The control technology course covers the following sequence in the early stages:

1. structures;
2. electricity;
3. electrical switching; and
4. electronics.

In the next stages the student is given freedom to choose, design, model, or build a major project. Construction kits are often used, such as Meccano, Fishetechnik, Proto, Lego, and

Danum Trent. In the modular courses students study structures, mechanisms, electronics, pneumatics, and aeonautics (pp. 5-15).

The National Centre for School Technology at Trent Polytechnic and the Mobile Technology Unit at Carlton, Bedfordshire provide support for the local education authorities for implementing the study of technology. As part of their work to teach technology, the National Centre for School Technology developed a theory of problem solving as a method for solving technological problems.

Haimes (1971) listed seven aims of technology for the United Kingdom schools:

1. to encourage pupils to be inventive, and to produce original and imaginative work;
2. to help pupils analyze a new situation and decide upon the significant factors;
3. to help them (pupils) to apply their knowledge of principles and procedures in reaching a possible solution, or solutions;
4. to give experience in planning and constructing devices so conceived;
5. to train pupils to recognize the limitations of a design and to suggest modifications;
6. to promote confidence in the use of unfamiliar and possibly complex equipment; and
7. to encourage pupils to keep faithful and methodical records, of failures as well as of success (p. 6).

Netherlands

In 1978 technology education was introduced to junior vocational education by a government resolution. In the middle school, technology is also one of the subjects to be taught. In 1985, technology was allowed to be introduced as an experimental subject into other types of secondary education: junior and senior secondary schools and in pre-university education. The curriculum for technology education is divided into five domains:

- technology education is aimed at teaching the pupils knowledge of and insight into phenomena (including social phenomena) based on the so-called pillars of technology: matter, energy, and information;

- technology education offers the pupils the opportunity to develop technical thinking skills;

- technology education is aimed at teaching pupils to combine technical skills, knowledge and insights, so that they are able to function independently in an environment dominated by technical phenomena;

- technology education invites pupils to develop a positive critical attitude toward the possibilities and means of technical progress; and

- technology education teaches pupils to deal with technical products in a responsible way (p. 193).

Raat (1986) investigated the concept of and attitude toward technology. The result of his effort was the Pupil's Attitude Toward Technology (PATT) Workshop. The purpose of the workshop and research effort was to organize a worldwide study of pupil's attitudes toward technology. The primary concern was to assess the feasibility of developing one instrument of measure, to assess the concept pupils have of the subject of technology, and to assess its relationship to the design of the subject technology. The Likert attitudinal questionnaire contained seven scales: (1) consequences of technology, (2) sex differences, (3) interests in technology, (4) technology in the curriculum, (5) difficulty/assessibility of technology, (6) creativity in technology, and (7) careers in technology. The project communicates through a newsletter and meet as a group annually.

Federal Republic of Germany

The Federal Republic of Germany emphasizes technology education program is on planning, organization, and calculation. Eliadis, (1980) stated:

> according to "arbeitslehre" the teachers do not give constructive assignments to students, but the students associate their projects with the technical, economic and civic dimensions of the real world, applying a practical theoretical process which includes: planning, organization, calculation (p. 3).

Voelmy (1971) identified four objectives for technology education in the Federal Republic of Germany:

1. to give pupils elementary technical education, to prepare them to cope with the technical side of their environment at work and in the home;
2. to give pupils preliminary understanding of economic and social factors in the world of industry and work and to give them examples of the links between technical, economic, political and social elements;
3. to instill in pupils a proper attitude to work (determination, tenacity, open-mindedness, flexibility and adaptability, etc.) so that they can meet the requirements of their profession in cooperation with others; and
4. to give pupils an opportunity fo vocational guidance or to develop "vocational selection maturity" i.e., to enable them to make sensible choice of job (p. 3).

Therefore, technology education emphasizes students coping with their environment, linking the social, technical, and social element, attitude development, and guidance purposes.

France

In 1982-83 school year, Savary, Minister of Education, issued a decree to reorganize education with more emphasis on general education. As part of this decree, technology education became compulsory for all students beginning from the start of secondary schooling (Dundas-Grant, 1985, p. 259). This eliminated the narrow focus of vocational education to a more general approach through the study of technology, therefore, broading the student's knowledge and understanding of the world in which he/she lives. The technology education curriculum is linked very closely with mathematics and sciences.

> Technology, through its methods of analysis and synthesis, is therefore capable of establishing bonds between physics and mathematics, and awakening the curiosity and aptitudes of pupils to the immense field of experimental sciences (p. 5).

Payan (1971) also identified the role of technology education is bridging the gap between the arts and sciences (p. 7).

Japan

The Japanese system of education emphasizes the study of technology primarily through the study of mathematics and science. There is a heavy trend toward a strong vocational education component, instead of a general approach to education. Oshiro (1975) reported that industrial arts in Japan has primary emphasis on the "technological aspects of a modern society, and is not concerned with the interpretation of industry and its socio-economic implications" (pp. 3-4). Industrial arts is only taught at the junior high school level, grades seven through nine. The program emphasis is, for the most part, on crafts. There is some instruction in elementary electricity and woodworking. Interestingly, industrial arts and vocational education in Japan do not have any relationship.

Synthesis of International Technology Education

Internationally, for the most part, technology education is a part of general education. In many countries, study of technology is more holistic in nature than is evident in the United States. However, like the United States, their study of technology is based on "learning by doing." Usually, design, control, and problem solving approaches drive the curriculum. The curriculum usually is built on the relationships between people, economical, political, societal and environmental issues. However, the primary purpose of technology education is to broaden the student's knowledge and understanding of the world in which he/she lives.

Technology education, in many countries, is considered a part of all children's education. This includes a strong emphasis on the study of technology at the elementary school level. There is also a distinct relationship between science and technology. The curriculum places great emphasis on understanding and applying knowledge to technological problems. From the historical perspective of curricular organizers outside and within industrial arts/technology education and internationally, it is crucial to understand the research technique employed in this study. Therefore, an examination of the Delphi Technique, its background, validity and reliability, advantages, limitations, steps in using the process, panel selection, willingness of the panel, and educational applications will be described.

Delphi Technique

The Delphi Technique is an effective method to gain a consensus of opinion regarding future trends and projections through a systematic process. The process involves an interaction between the researcher and a group of selected experts on a given topic of study, usually through a series of questionnaires (Skutsch and Hall, 1973). The Delphi Technique replaces committee activity with a well designed structure of individual interrogation (Helmer, 1963, p. 76).

Skutsch and Hall (1973) identified the Delphi Technique as a method for gaining judgments on complex matters that precise information is not available. Linstone and Turoff (1973) stated that the Delphi Technique as "Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" (p. 3).

Pfeiffer (1968) outlined the basic Delphi process:

1. the first questionnaire that is sent to the panel of experts may call for a list of opinions involving experiences judgements, a list of predictions, and a list of recommended activities;
2. on the second round, each expert receives a copy of the list and is asked to rate or evaluate each item by some criterion as important, probability of success, and so on; and
3. the third questionnaire includes the list and the ratings indicated and the consensus, if any, and in effect asks that the experts either revise their opinion or else discuss their reason for remaining outside of the consensus.

Background

The Delphi Technique can be traced back to the 1930's. Israeli (1930, 1932, 1933, 1934, 1936) and McGregor (1938) used a modified Delphi Technique to make predictions. However, the Delphi Technique as we know it today was developed by Helmer and colleagues during the 1950's at the Rand Corporation. Dalkey and Helmer (1962) provided the first to use the Delphi Technique when they solicited opinions for the military from seven experts on atomic warfare. Helmer (1963) published a comprehensive review of the process.

The first non-military use of the Delphi Technique was done by Gordon and Helmer (1964) to forecast technological events. Adelsen and colleagues (1967) provided a Delphi application to education. Campbell (1966) used the Delphi Technique in industry, Reisman and associates (1969) in community planning, and Dean and Mathis (1969) in research projects.

Dalkey (1967) identified basic characteristics of the Delphi Technique:

1. *Anonymity*. Anonymity is achieved by using questionnaires or other channels of communication where specific responses are not associated with individual members of the group.
2. *Interaction with controlled feedback*. Interaction consists of performing the interaction among members of the group in several states: typically at the beginning of each stage the results of the previous stage are summarized and feedback to the members of the group, and they are then asked to reassess their answers in light of what the entire group thought on the previous round. Controlled feedback allows interaction with a large reduction in noise.
3. *Statistical group response*. Finally, the group opinion is taken to be a statistical average of the final opinions of the individual members of the group....By using a statistical group opinion, and probably more important, the opinion of every member is reflected in the group response (pp. 8-9).

Weaver (1971) characterized the Delphi Technique as an "intuitive methodology for organizing and sharing expert forecasts about the future" (p. 267). Johnson and colleagues (1973) concluded that the Delphi Technique relative to the field of education is increasing. Pallante (1976) provided a rationale for using the Delphi Technique for curriculum development:

> Perhaps most significant, the technique has generally been used to produce what *will* happen rather than to seek agreement concerning what *should be*. In conclusion, the Delphi Technique is a method for systematic solicitation and collection of expert opinions. It is applicable when-

ever policies and plans have to be based on informed judgments; it is applicable to virtually any decision-making process (p. 89).

Starkweather (1975) identified ten characteristics of the Delphi Technique:

1. the technique was found to be appropriate for eliciting and refining their opinions group of people;
2. the procedure allowed for the anonymity of responses, thus reducing the effect of any dominant individual;
3. the Delphi technique permitted controlled feedback from the panel of experts;
4. a meaningful results could be attained in the time available with the resources at hand;
5. the procedure allowed the panel of experts to take advantage of relevant information in setting guidelines for direction for the future of industrial arts;
6. the technique could be used on a nation-wide basis;
7. the Delphi had promise for addressing itself to several pertinent issues at once while synthesizing the findings of each issue;
8. the procedure could be used to gain consensus of the potential directions of industrial arts toward the year 2000 A.D. and for gaining consensus as to when each issue will have the most effect on industrial arts in the educational system;
9. the time between rounds of the Delphi Technique gave the experts time to reflect upon their previous responses and make changes during subsequent mailings; and
10. Assemblying the experts for a conference would have necessitated a greater expense than mailing the questionnaire (p. 50).

Four objectives for the Delphi Technique were identified by Strauss and Zeigler (1975):

1. to explore or expose underlying assumptions or information leading to differing judgments;

2. to seek out information that may generate a consensus of judgment on the part of the respondent group;
3. to correlate informed judgments on a topic spanning a wide range of disciplines; and
4. to educate the respondent group as to the diverse and interrelated aspects of the topic (p. 254).

Sackman also stated objectives of the Delphi Techniques: forecasting of specified events, long term or short term; the generation of quantitative estimates from a set of participants; and aimed at qualitative evaluations (1975, p. 8).

Validity and reliability of the Delphi Technique. The validity and reliability of the Delphi Technique has been examined as an appropriate method of forecasting future trends. With regard to validity, Helmer (1967) stated:

> Validity may be considered established only in an intuitive sense in that those participating in such an experiment appear satisfied that the method is both fair and efficient in obtaining the information collectively possessed by the group (p. 5).

Similarly, Pfeiffer (1968) examined the Delphi procedure against the simple questionnaire approach. He concluded that the Delphi produced more accurate results than did the simple questionnaire method (p. 82). Webb (1966) concluded that the three round Delphi produced credible data and findings.

Dalkey and colleagues (1972) investigated the reliability of the Delphi Technique and noted:

> In general, one would expect that in the area of opinion group responses would be more reliable than individual opinions, in the simple sense that two groups (of equally competent experts) would be more likely to evidence similar answers to a set of related questions that would two individuals. This similarly can be measured by the correlation between the answers of the two groups over a set of questions. But the assertion that groups will be more reliable than individuals is not a tautology. It depends on the distribution of answers that would be obtained from the total population of potential respondents, and it depends upon the method of selecting the

subgroups out of this population....It is clearly desirable for a study that another analyst using the same approach (and different experts) arrive at similar results.

Brown and Helmer (1964) studied ways of improving the reliability of estimates obtained from a consensus of experts. They concluded that:

1. the subjects were relatively inexpert with regard to the questions posed;
2. convergence opinions was quite noticeable - the spread as defined by the interquartile range shrank to less than one half during the experiment - but it may have been induced to an undesirablly large extent by the experimental procedure;
3. convergence of the medians to the true values occurred in the majority of cases; and
4. the use of self-appraised competence ratings in forming a consensus appeared to be a more powerful tool for increasing reliability of the group estimates (p. 12).

Conversely, others have criticized the validity and reliability of the Delphi Technique (Sackman, 1978, p. 186; Hill and Fowles, 1975, p. 181; and Linstone, 1978, p. 279).

Advantages of the Delphi Technique. Rossman and Bunning (1978) listed strenghts of the Delphi Technique:

1. it avoids persuasion, leadership influences, hidden agents, personality conflicts, and other problems encountered in group decision making;
2. it allows a variety of individuals, perhaps widely separated geographically, to anticipate equally; and
3. it provides documentation, including minority opinions.

Mandanis concluded that the Delphi Technique would provide the participants a learning experience not available by other means (p. 165).

Weatherman and Swenson (1974) noted five advantages of the Delphi Technique. They suggest that the Delphi Technique:

1. provides a means of obtaining information from a large number of persons, without restrictions imposed by geography;
2. is easy to administer and relatively low in cost;
3. provides a means of obtaining information about particular complex phenomena, which are often difficult to conceptualize;
4. focuses attention on the desired topic areas; and
5. permits a high degree of control by the survey manager.

Combs (1985) listed similar advantages of the technique. The Virginia Cooperative Extension Service of Virginia Tech concurred with the previous listed advantages.

Others have identified advantages of the Delphi Technique:

1. The technique is simple to use. Advanced mathematical skills are not necessary for design, implementation, and analysis of a Delphi project (Strauss and Zeigler, 1975).

2. As the Delphi provides anonymity, many psychological barriers to communicate are overcome, such as reluctance to state unpopular views, to disagree with one's associates, or to modify previously stated positions (Enzer, 1970; Pfeiffer, 1968).

3. The Delphi provides a framework within which individuals with diverse backgrounds can work together on the same problem (Enzer, 1970).

A major strength in the technique is the flexible, but limited, time paramenters that individuals have in which to respond at their own convenience. This flexibility allows persons to participate who perhaps would not be willing to share their time under other conditions (Brooks, 1979).

Limitations of the Delphi Technique. Others have criticed the Delphi Technique as a procedure for predicting the future. Bernstein listed four disadvantages of the technique for forecasting the future:

1. difficulties in mail communication;
2. possible distortions due to the selection of participants;
3. lack of assurance that a particular criterion of consensus will be reached; and

4. the semantic analysis of Probe I (the inductive approach always presents a problem of interpretation and proper statement diagnosis for the following probes).

The Virginia Cooperative Extension Service of Virginia Tech listed basic disadvantages of the Delphi Technique:

1. judgments are those of a selected group of people and may not be representative;
2. tendence to elimate extreme positions and force a middle-of-the-road consensus;
3. more time consuming than the norminal group process;
4. should not be viewed as a total solution;
5. requires skill in written communication;and
6. requires adequate time and participant commitment (about 30 to 45 days to complete the entire process) (1986).

Similarily others cite limitations to the Delphi Technique as a method of predicting the future:

1. Delphi's are slow and take a long period of time to execute and complete the series of questionnaires (Brooks, 1979; Rossman and Bunning, 1978; Strauss and Zeigler, 1975).

2. Considerable administrative work is associated with the technique, such as (a) the maintenance of individual records ford each respondent to determine changes and prior ratings, (b) the preparation and mailing of several questionnaires, and (c) the tabulation of data (Cyphert and Gant, 1970, p. 422).

3. The panel of experts could be too homogeneous or likeminded, producing a skewed data set (Strauss and Zeigler, 1973).

4. The Delphi offers little explanatory power, except dissenting opinions. The researcher has no way of knowing why one response was selected over another or why participants moved to consensus (Rasp, 1974, p. 325).

Even though the Delphi Technique does have some limitations, Combs (1985) pointed out that the advantages outweigh the disadvantages.

Based on the advantages and limitations of the Delphi Technique, it is important to determine when the technique is appropriate and when the technique is not appropriate. The Delphi appears to be appropriate when:

1. The respondent group has very limited time to devote to the effort because of other commitments (Turoff, 1970, p. 1).

2. Questions to be answered by intuitive judgment supersede questions to be answered by concreted measurement (Pill, 1971, p. 62).

3. There is no way of immediately confirming the results (Pill, 1971, p. 62).

4. The questions are subject to many interpretations and thus cannot be found through traditional patterns of research (Pill, 1971, p. 62).

5. The desirability of overlooking some facet of a question can be minimized by diversity of group opinions (Pill, 1971, p. 62).

6. A cross fertilization of opinion is desired which may lead to many innovations and breakthroughs (Brown and Helmer, 1971, 1964).

7. The expertise of a group is more desirable than the opinion of a single expert (Pill, 1971, p. 62).

8. The situation requires quantification or ordering of subjective variables.

9. Disagreement may exist among the experts to the extent that a referred communication process is desired (Turoff, 1970, p. 2).

10. It is used to minimize the psychological aspects of face-to-face confrontation (Pill, 1971, p. 64).

11. There is a high level of uncertainty involved (Pill, 1971, p. 63).

The Delphi Technique appears not to be appropriate when:

1. There is insufficient structure in the questionnaire implying that not enough information is available to the Delphi participants (Turoff, 1970 p. 2).

2. The opinion of the real expert is diluted by the consensus of the group (Pill, 1971, p. 62).

3. Results are immediately verifiable by some other means (Pill, 1971, p. 63).

4. It is used for any purpose other than that of combining opinions of a selected group (Pill, 1971, p. 63).

5. Consensus may be gained by any means other than intuitive judgment.

Steps in using the Delphi Technique. Brooks (1979) identified the following steps in using the Delphi Technique:

1. Panel of experts is identified.
2. The willingness of the individuals to participate is determined.
3. Individual input on a given issue is gathered and combined into basic statements.
4. The data provided by the panel are analyzed.
5. The assembled group input (questionnaire) is mailed to each panel member for assessment.
6. The new input is analyzed by the researcher. The results, indicating the distribution of responses, is returned to the panel.
7. Each participant is asked to examine the data and to reassess his own position based on the group's responses. A participant whose personal position varies significantly from the group norm is asked to provide a rationale to support the divergent view. The length of the rationale (remarks) is limited to keep responses brief.
8. The input is analyzed by the researcher. The input is shared, in addition to the minority supporting statements, with the panel. Each member is asked again to review his position; and, if still not within a specified range, to support that position with a brief rationale (pp. 377-378).

Brooks also concluded that three rounds were significant to gain a consensus of opinion and that the fourth round produced very little change, if any.

The Panel

The selection of the panel of experts is a crucial factor in the success of a Delphi study (Enzer and Brigard, 1970, p. 62). Helmer listed three key considerations when dealing with experts. They are (1) select your experts wisely, (2) create the proper conditions under which they can perform most ably, and (3) if you have several experts on a particular issue available, use considerable caution is deriving from their various opinions a singled combined position" (Helmer, 1967, pp. 4-5). Hales (1972) noted that a "demonstration of knowledge by virtue of position" is probably the best criteria for selecting an expert p. 23).

Pyke (1970) stated:

> Expert opinion, which can be extremely useful in the solution of a variety of problems, is particularly valuable in the preparation of forecasts. The expert has a good feel for historical trends in this specialty....He is undoubtedly well aware of significant research which is underway in his field and of the potential benefits likely to be derived therefore, and he has probably given some thought to contributions which might be expected from his specialty in response to various socio-economic stimuli (p. 143).

However, Welty (1972) reported that very little research has been done in the area of selecting a panel of experts (p. 121).

Gordon (1971) pointed out the importance securing a panel that are committed and willing to serve as panelists (p. 14). Cyphert and Gant agreed with Gordon as this being crucial to the success of the Delphi study (Hillestad, p. 72).

Martino (1968) stated that the panel must be administratively workable and that the panel not be too large. However, Martino did not specify a particular size for the panel (p. 138-144). Likewise, Dalkey was concerned with the proper size of the panel. He contended that the size should be between 17 and 29 (p. 11).

Educational Applications of the Delphi Technique

Delphi studies have been done for education purposes since 1967. For the most part they have concentrated in one of the following areas: (1) technological innovations, (b) events impacting on education institutions, and (c) events impacting on industrial institutions (Halfin, 1973, p. 10). This supports Judd's (1972) and Hostrop's (1973) findings.

Among the initial Delphi studies conducted in education were done by Adelsen (1967), "Innovation in Education" and Helmer (1967), *Inventing Education for the Future*. Adelson's research was used to determine different perspectives for American education. Helmer's work looked at technological innovations.

Reisman (1969) and Hearon (1970) studied cost-benefit analysis. Bolman (1971) examined curriculum and campus planning through the Delphi method. Cochran (1970) looked at the issue of teacher education. A University of Massachusetts at Amherest and the Mawsachusetts Department of Education used modified four round Delphi to determine teacher and administrator needs (Rossman and Carey, 1973).

The Delphi Technique has also been used to identify educational goals and objectives. Hudspeth (1970) conducted a state-wide Delphi to determine the future goals and objectives of higher education in New York. Uhl (1970) examined an on-campus and off-campus group to solicit their opinions of their institution. Norton (1970) used the Delphi method to gather opinions for the Governor's Need Assessment Survey and Peterson (1970) conducted a followup to Uhl's study. Anderson utilized the Delphi to identify goals of a local school district in Ohio. Cyphert and Gant (197) used the Delphi to identify the goals of the School of Education at the University of Virginia.

Bentley (1971) similarly used the Delphi to identify goals for an urban school district. Sweigert and Schabacker (1974) used a modified Delphi to establish educational goals for Atlanta. Corbin (1976) utilized a modified Delphi to determine goals and objectives for the high school division of the Distributive Education Clubs of America.

The Delphi Technique has also been used to determine competencies for program areas and teacher characteristics. Gray (1970) conducted a study to determine competencies for program planning. Starr (1974) examined teacher competencies using this technique. Brown (1971) determined characteristics of business education teachers. Chaney (1972) studied the characteristics of effective behavior of student teachers of skilled subjects in business.

Copeland (1977) used a three round Delphi to identify teacher competencies for evaluating industrial arts student teachers. He used a 5 point Likert scale to rate each item and he used a 80 percent acceptance level for an item to be in agreement. His analysis of data included: (1) the Wilcoxon matched-pairs signed ranks test for reliability of ranking, and (3) the Kendall's coefficient of concordance for comparing rank orders of the three groups used in the study.

Future studies in the field of education have also been conducted through the Delphi. In one such study, Jacobson (1970) investigated how to design education for the future. Cunico (1974) looked at the future of industrial education, using a three round Delphi technique. He used a Likert scale to rank each item with the lowest mean representing the highest consensus of opinion. An analysis of variance was used, indicating the significant difference at the .05 level of significance and a F ratio above 3.09.

Using a five round Delphi, Starkweather (1975) gathered opinions on the future direction of industrial arts toward the year 2000 A.D. Starkweather analyzed the data collection under four major headings: "(1) Statements related to the future of Industrial Arts Analyzed According to the Median Percent of Projected Student Population to be Affected During Selected Time Periods from the Years 1975-2000; (2) Statements Related to Industrial Arts Having a Median of 50 Percent or Higher of the Projected Student Population to be Affected at Anytime During the Years (1975-2000; (3) Statements Relating to Industrial Arts Analyzed According to Three Categories of Projected Student Population Medians; and Analysis of Statements Related to the Future of Industrial Arts During 1975-2000 Time Period" (pp. 550-56).

In the first round, Starkweather used basically an open-ended approach, providing very little structure other than an example. A probability of occurrence indicator was used in the second round, with a mean calculated for each item. Items falling below a mean of 4.0 were deleted, with the remaining items representing a consensus of opinion of the panel of experts.

Combs (1985) also utilized the three round Delphi to solicit opinions relative to possible futures of the public secondary school. The jury rated items according to their probability of occuring.

Finally, the Delphi has been used to determine curriculum content. Halfin (1973) examined the study of technology as a process approach, using a three round Delphi. Lawrence (1980) applied the Delphi Technique to determine the curriculum content for automotive technologist. Again, Lawrence used a four round Delphi Technique and a Likert scale for rating the items of the questionnaire. The Kendall's coefficient of concordence (W) was conducted for rounds II, III, and IV that showed an increase in W with each round. This indicated a move toward agreement among panelist.

Gomez (1985) similarly used a three round Delphi, with a Likert rating scale to determine the curricula for computer science at the secondary level. The results of the study were under three categories: (1) results related to definition, (2) results related to curriculum, and (3) results related to support essentials (p. 87).

Method of Equal Appearing Intervals

The method of equal appearing intervals has been widely used to force choice opinion and obtain scale values on a large number of statements (Edwards, 1957, p. 83). Thurstone and Chave (1929) initially developed the method of equal appearing intervals by asking a group of judges to sort statements into intervals. They used eleven intervals, ranging from less favorable to very favorable. Thurstone and Chave found that approximately 130 statements could be sorted in 45 minutes. To calculate how one item compared in relation to all other items, they used the median of the distribution for a given statement.

To understand the basic procedure of the Thurstone and Chave method of equal appearing intervals, it is necessary to examine the key steps in the procedure. Sidowski (1966) outlined the basic steps in the Thurstone and Chave equal appearing intervals as:

1. The formulation of a large number of statements about the attitude object;
2. The sorting of these items into eleven piles by judges according to their estimate as to whether (and to what degree) ascent would reflect favorable, neutral, or unfavorable attitudes toward the objects;
3. Computation of the median scale position of each item based upon judges' sorting; and
4. Rejection of items for which there is insufficient agreement among judges (p. 613).

Any time a group of individuals are asked to make force choices on a subject, safeguards need to be considered to insure proper usage of the technique. Travers (1951) critically reviewed the validity and rationale of the force choice technique. He concluded that defects do not occur because of the technique, but rather because of improper usage. It was noted by Travers that there is always danger when people are asked to make force choices on a subject. He pointed out that behaviors vary in frequency with behavior which vary in degree.

According to Seager (1959), the "Q sort technique then presupposes a theoretical framework and allows analysis only of those variances and behavior between individuals which are described in the theory if the theoretical framework is actually stated in a balanced block design (p. 66). He supported the use of a pilot test of the instrument to determine if the data received were manageable. To insure this, Seager recommended concise instructions and example.

Much research has been conducted to determine the required number of judges needed for the method of equal appearing intervals. Thurstone and Chave (1929) used 300 judges to sort 130 statements relative to attitudes toward the church. Others contend that a smaller number of judges can produce reliable data (Edwards, 1957, p. 94). For example, Rosander (1936) only used fifteen judges.

The method of equal appearing intervals has been used for gathering data for educational purposes. Most notably are the three companion studies conducted in 1959 at the University of Chicago by Downey, Seager, and Slagle. They were collectively researching the task of public education from three perspectives: (1) regional sub-publics, (2) proximity sub-publics, and (3) occupation and age sub-publics. The studies focused on two broad purposes: (1) to identify the elements of the task of public education, and (2) to determine the extent to which the public perceived those elements to be important aspects of the task of public education (Downey, 1960, p. 6). Part of the study was replicated by Grove (1969) in determining the task of public secondary schools as perceived by school-community sub-publics in a midwest urban city.

In conclusion, the Delphi technique is an effective and systematic way of gaining consensus of opinion on future trends. The technique has been used since the 1930's and has been used in many educational studies over the years. The Thurstone and Chave Equal Appearing Interval Scale provides a means of forcing opinion through a comparison of an item against all other items. Therefore, through this approach, the data gathered can be considered highly reliable.

Summary

Chapter II reviewed the literature relative to the research topic. The review of literature was subdivided into six major headings for examination: (1) what is technology, (2) what is technology education, (3) a historical perspective of curricular organizers outside industrial arts/technology education, (4) a historical perspective of curricular organizers within industrial arts/technology education, (5) an international perspective of curricular organizers within technology education, and (6) the Delphi Technique.

In defining technology the author examined the derviation of the term and some classic dictionary definitions of the term technology. From that basis the author then explored varying viewpoints relative to the definition of technology to show the need to understand exactly what is meant by technology because of its divergent or esoteric opinion of what technology really is. The definitions related in the context of engineering, applied science, praxiology, history of technology, anthropology of technology, and industrial arts/technology education.

The section on technology education outlined the principal philosophies, objectives, goals and foundation concepts for the study of technology. The review highlighted views within and outside industrial arts/technology education.

In examining the historical perspective of curricular organizers outside industrial arts/technology education, the author limited the review to curriculum projects that were developed as a result of the technological advancement and emphasis that occurred because of the successful launch of Sputnik I. The review covered the subject areas of mathematics, science, social sciences, future studies, and interdisciplinary approaches. The historical perspective of curricular organizers within industrial arts/technology education reviewed the evolution of the foundation for the study of technology relative to industrial arts/technology education.

The review of the section on an international perspective of curricular organizers within technology education included the rationale for international technology education and its foundation principles. The section also contained a look at technology education in the United Kingdom, the Netherlands, the Federal Republic of Germany, France, and Japan.

The Delphi Technique section covered basic background information relative to the Delphi Technique, its validity and reliability, advantages, limitations, steps in using the process, selection of the panel, willingness of the panel, and educational applications of the Delphi Technique.

Chapter III will outline the research procedure to be used in this study.

CHAPTER III. THE DESIGN OF THE STUDY

Chapter III delineates the design of the study. The research methodology presented will be utilized to gather data on the two following research questions:

1. Looking into the future, what will be the key descriptors of a definition for technology and
2. Looking into the future, what will be the appropriate curricular organizers for the study of technology?

This chapter includes procedures used in the preparation of the study and the conduction of the research. The concept for the topic of the study was derived from research, based on a continuous review of literature and discussions with authorities inside and outside the field of technology. The Delphi Technique was selected as the method to the conduct research, since the researcher was interested in gaining a consensus of opinion on the topic of study from experts inside and outside the field of technology. The proposal was presented to the researcher's doctoral committee for their acceptance and for further recommendations.

Procedures Used in Preparation of the Study

A three round Delphi Technique was used to conduct the research for the study. Since the study was designed to inquire into the field of technology, the following Delphi panels were recommended from the interviews and by the researcher's doctoral committee: (1) technology education professionals, (2) industrialists/business leaders, (3) futurists, (4) historians of technology, (5) philosophers of technology, (6) anthropologists of technology, and (7) philosophers of education. Each panel consisted of five members. The first round instrument was sent on October 9, 1986 to all panelists to gain their opinions on the research questions. After the panelist's opinions were compiled and classified, the second round instrument was sent on October 30, 1986 to each panel to gain consensus of each panel. The opinions were again compiled and classified. The third round was sent on November 25, 1986 to each group. The opinions were compiled and classified. An analysis of the data was then conducted.

Each round called for a ten day turn-a-round period once the expert received the instrument. To ensure this, a postcard was mailed to each expert as a reminder five days after the instrument for that round had been mailed. Two days after the deadline for a round, a follow-up telephone call was made to each expert whose instrument had not been received. Following the completion of the third round and data analysis, the final results were sent to each participant.

Validation of the Procedure as Being Representative of the Delphi Technique. To ensure that the Delphi procedure established was valid and would yield significant results, the researcher used the following method:

1. A review of the literature was conducted to understand the educational applications of the Delphi Technique and how it could be best used in this study.

2. The Delphi procedure was established by the researcher's review of the literature and it was approved by the researcher's doctoral committee.

3. The Delphi instrument was reviewed by a panel of Virginia Tech faculty members to ensure clarity and to confirm that the right questions were being ask of the panel of experts.

Selection of the Panel of Experts. From the review of literature and recommendations from the people interviewed, the researcher developed a list of experts for each Delphi panel. The researcher then identified an expert in each category to review the list for that panel and to recommend ten experts from the list or others they felt more appropriate. Following this step, the experts were selected for each panel by a random draw of names from a hat. The first five names drawn for each panel served as the panel of experts for that group, the other five names served as alternates. The panelists selected were contacted by telephone to ask if they would be willing to serve as a panelist for the study. If a selected expert could not serve, the first alternate was called as a replacement, and so on until five experts represented each panel.

If, for some reason, a panelist decided not to continue once the study had begun, the panelist had to state specific reasons for doing so in writing. Another expert was selected at random to replace the panelist provided the first round had not been completed. After the first round, panelists were not replaced.From this selection process, the following participants completed the study:

Technology educators. The technology educators consisted of five panelists:

Thomas A. Hughes - Mr. Hughes is the Associate Director of Technology Education for the Commonwealth of Virginia. He has served as President of the International Technology Education Association and has been recognized by his peers with many leadership awards.

Geoffrey B. Harrison - Dr. Harrison is the Director of Technology Education at the National Center for School Technology at Trent Polytechnic in the United Kingdom. He is considered by many as the founder of the technology education movement in the United Kingdom.

Jan H. Raat - Dr. Raat is the only professor of technology in the Netherlands. He is currently a professor at Eindhoven University of Technology, where he also is conducting international research on pupil's attitudes toward technology.

M. James Bensen - Dr. Bensen is the Dean of the School of Industry and Technology at the University of Wisconsin - Stout. He is the President of the International Technology Education Association.

Ronald D. Todd - Dr. Todd is the Coordinator of Technology at New York University - Washington Square. He also coordinates the Technology Abroad Program that has established cooperative assignments with the Deutches Museum, Munchin, West Germany, and the National Centre for School Technology, Trent Polytechnic; The Division of Science and Technology; Her Majesty's Inspectorate, and Oxford University, United Kingdom.

Philosophers of education. Two philosophers of education completed the study:

Jack Frymier - Dr. Frymier is currently a Senior Fellow at the International Headquarters for Phi Delta Kappa. He is a former professor of curriculum and instruction at The Ohio State University.

Harold G. Shane - Dr. Shane is a professor of education at Indiana University. He is a former President of the World Future Society and has authored many articles and books on future curricular changes for education.

Philosophers of technology. Like the philosophers of education, only two panelists in this group completed the study:

Paul T. Durbin - Dr. Durbin is a professor of philosophy at the University of Delaware. He has authored many articles on philosophy. He has been the co-editor of numerous yearbooks on the philosophy of technology.

Alex Micholos - Dr. Micholos is a professor of philosophy at the University of Guelph in Ontario, Canada. He is the author of numerous articles on the philosophy of technology.

Anthropologists of technology. Four panelists in this group completed the study:

Willis E. Sibley - Dr. Sibley is a professor of anthropology at Cleveland State University. He is the liaison person from the Society for Applied Anthropology to the American Association for the Advancement of Science.

Marietta L. Baba - Dr. Baba is the Associate Provost and an associate professor of anthropology at Wayne State University. She has also served as an associate professor of science and technology and as a member of the Michigan Technology Council.

Wendell H. Oswalt - Dr. Oswalt is the chair of the Department of Anthropology at the University of California, Los Angeles. He has published extensively in the area of technology and anthropology.

Edward Knipe - Dr. Knipe is a professor in the Department of Sociology and Anthropology at Virginia Commonwealth University. He, like Oswalt, has published numerous manuscripts on anthropology and technology.

Historians of technology. The historians of technology included four experts who complete the study:

Terry S. Reynolds - Dr. Reynolds is an associate professor and Director of Program in Science, Technology, and Society at Michigan Technological University. He has been active in the Society of the History of Technology and serves on the Advisory Board of St. Martin's Press for its publication *Great Engineers and Pioneers of Technology Project*.

Alex Roland - Dr. Roland is the Secretary of the Society for the History of Technology and is an associate professor of History at Duke University. He has authored many publications on aeronautical and space history.

Jeff Sturchio - Dr. Sturchio is the Acting Director of the Center for the History of Chemistry at the University of Pennsylvania. He is the author of many publications and has been very active in the Society for the History of Technology.

Stephen Cutcliffe - Dr. Cutcliffe is the Director of the Science, Technology, and Society Program at Lehigh University. He is also the editor of Lehigh's STS Newsletter.

Futurists. Four futurists completed the study:

Robin Roy - Dr. Roy is a Senior Lecturer in Design at The Open University, Milton Keynes in the United Kingdom. He has conducted extensive research in design technology and was highly involved in the development of technology education in the United Kingdom.

Joseph F. Coates - Mr. Coates is the President of J. F. Coates, Inc., a policy research organization specializing in the future. He is the former Assistant to the Director and Head of Exploratory Research at the Congressional Office of Technology Assessment. He has also served as an adjunct professor at George Washington University on technology and the future.

Selwyn Enzer - Dr. Enzer is the Associate Director of the Center for Futures Research at the University of Southern California. He is internationally known for his research in futures methodology, strategic planning and technology assessment.

Christopher J. Dede - Dr. Dede is founder of the educational division of the World Future Society. He has been a speaker and consultant in Norway, Hungary, Romania, Yugoslavia, Germany, Mexico, and Greece. He has conducted extensive research in the curriculum of the future.

Industrialists/business leaders. In this group, four experts complete the study:

James R. Johnson - Dr. Johnson is the former Vice President for Research for the 3M Corporation. He has also served on the Advisory Council for the International Technology Education Association and is presently serving as the Chair of the Technology Commmittee for Project 2061.

Forrest D. Brummett - Mr. Brummett is a Chief Engineer at Detroit Diesel Allison Division of the General Motors Corporation. He is the Past International President of the Society of Manufacturing Engineers and has served on their Board of Directors for the past 12 years.

George L. Fricke - Mr. Fricke is responsible for all corporate training and development for New Jersey Bell. He is the Chair of the New Jersey State Commission on Technology Education.

W. Lincoln Hawkins - Dr. Hawkins is the former Research Director for the Plastics Institute of America. He has served in several faculty and technical consulting positions both nationally and internationally.

Conduct of the Research

The Delphi procedure used in this study parallels the research of Helmer (1963, 1967), Dalkey (1967), Gordon and Helmer (1964), Linstone and Turoff (1973), Day (1978), Webb (1966), Scheele (1975), Brooks (1979), and Thurstone and Chave (1929). A review of doctoral dissertations on education that have used the Delphi Technique was also conducted. They were consistent with the research of the aforementioned experts. The research procedure for this study consisted of a three round Delphi to gain consensus of opinion on the two key research questions: (1) Looking into the future, what will be the key descriptors of a definition for the study of technology and (2) Looking into the future, what will be the appropriate curricular organizers for the study for technology?

Although Helmer (1963), Dalkey (1967), and Gordon and Helmer (1964), in their original work for the Rand Corporation, identified the use of a four or five round Delphi procedure, the research procedure for this study was supported by the work of Webb (1966), Brooks (1979), and Pfieffer (1968). They contended that a three round Delphi will produce credible data and findings. The three round Delphi is also supported by numerous Delphi studies in the field of education (Halfin, 1973; Corbin, 1976; Copeland, 1976; Gomez, 1985; and Combs, 1985).

For each round, measures were taken to prevent attrition and to increase the response. The Delphi I was mailed to each panelist within one week after all experts agreed to serve on the jury. The second and third round instruments were also mailed to the panelists within one week after all responses had been received from the previous round. A follow-up postcard was sent to all experts on the fifth day after the Delphi instrument for that round was mailed. A follow-up telephone call was conducted to each panelist whose instrument had not been received two days after the deadline for that round.

The first round served to gain a general consensus of opinion of all panelists. The first round was open-ended. The open-ended approach to the first round was used by Day (1978) in the Bell Canada Study. This technique was also supported by the basic Delphi procedure outlined for the first round by Pfieffer (1968). The Delphi I gave a description of the purpose and requirements of the first round instrument. An example was provided for clarity. Scheele (1975) emphasized the importance of providing the expert with a clear and concise description and a concrete example to clarify the Delphi instrument.

Each expert was asked to answer the two research questions in brief and concise statements or lists. Once all responses were received, they were compiled under their appropriate research question. All responses were reviewed to avoid redundant responses. Following this, all response items were retyped on Q sort cards as outlined in Thurstone and Chave's equal appearing interval scale procedure. This Q sort procedure then became the Delphi II instrument.

The Delphi II instrument was sent to each panel of experts. The instrument provided each expert with a description of the purpose and requirements of the second round instrument. An example was provided for clarity. For each research question, each panelist was asked to Q sort the items under each question, according to Thurstone and Chave's equal appearing interval scale procedure. A Thurstone and Chave equal appearing interval continuum was provided to aid the experts in sorting the items. The continuum consisted of 11 interval cards, ranging from card A to K. The A card represented unfavorable, the F card represented neutral, and the K card represented favorable. For both research questions, statements compiled from Delphi I were placed on separate cards. Each panelist was then asked to sort the statements along the A-K continuum, based on the increasing or decreasing degree of favorableness or unfavorableness.

Once all responses were received, they were reviewed to eliminate responses that were carelessly done or for those panelists who misinterpreted the instructions. A criterion was used that eliminated responses that placed 30 or more statements on any one card. A scale and Q value were calculated for each item, according to Thurstone and Chave's equal appearing interval scale procedure. To calculate the scale and Q values a Summary Table was used (Figure 1), with three rows being used for each statement. Row 1 gave the frequency with which a statement was placed in each of the 11 categories. Row 2 gave the frequencies as proportions (f/N), with N representing the number of judges. Row 3 gave the cumulative proportion.

Statements		Sorting Categories											Scale Value	Q Value
		A 1	B 2	C 3	D 4	E 5	F 6	G 7	H 8	I 9	J 10	K 11		
1	*f*													
	p													
	cp													
2	*f*													
	p													
	cp													
3	*f*													
	p													
	cp													

Figure 1. Thurstone and Chave Calculation Table (Edwards, 1957, p. 87).

The median of the distribution of judgments for each statement was the scale value of the statement. The scale value was calculated by the following formula:

$$S = l + \frac{.50 - \Sigma p_b}{p_w} i$$

where S	= the median or scale value of the statement
l	= the lower limit of the interval in which the median falls
Σp_b	= the sum of the proportions below the interval in which the median falls
p_w	= the proportion within the interval in which the median falls
i	= the width of the interval and is assumed to be equal to 1.0 (Edwards, 1957, p. 87).

The Q value measures the variation of the distribution of judgments for a statement. To calculate the Q value, the semi-interquartile range, the following formula was used:

$$Q = C_{75} - C_{25}$$

where Q = Q value

C_{75} - 75^{th} centile

C_{25} - 25^{th} centile (Edwards, 1957, p. 89).

The following formulas were used to obtain the 25th centile and 75th centile:

$$C_{25} = l + \frac{.25 - \Sigma p_b}{p_w} i$$

where C_{25} = the 25th centile

l = the lower limit of the interval in which the 25th centile falls

Σp_b = the sum of the proportions below the interval in which 25th centile falls

p_w = the proportion within the interval in which the 25th centile falls

i = the width of the interval and is assumed to be equal to 1.0

and

$$C_{75} = l + \frac{.75 - \Sigma p_b}{p_w} i$$

where C_{75} = the 75th centile

l = the lower limit of the interval in which the 75th centile falls

Σp_b = the sum of the proportions below the interval which 75th centile falls

dp_w = the proportion within the interval in which the 75th centile falls

i = the width of the interval and is assumed to be equal to 1.0 (Edwards, 1957, pp. 88-89).

The items under each research question were retyped on Q sort cards, with their scale and Q values. This constituted the third round instrument.

The Delphi III instrument was mailed to each expert. The third round instrument gave a description of the purpose and requirements of that round. Using the Q sort technique, the expert was asked to rank-order each item under its research question according to the Thurstone and Chave procedure. For any item with which the panelist could not agree, the expert furnished a written statement of explanation that the item should not be a part of the definition or the curricular organizer for the study of technology.

Once all responses were received, they were reviewed to eliminate responses that were carelessly done. A criterion was used that eliminated responses that placed 30 or more items on any one card. A scale and Q value were calculated for each item, according to the Thurstone and Chave procedure.

Analysis of the Data

All data for each research question were analyzed and listed in order of greatest consensus of opinion under the headings (1) the key descriptors of a definition for technology and (2) the appropriate curricular organizers for the study of technology. An Equal Appearing Interval Scale was used to assign a scale and Q value to each item from the Q sort conducted for each research question.

The items were ranked from highest to lowest scale value for each Delphi panel and for the cumulative total for each research question. The 80th centile was used as the breakpoint for an item gaining consensus of opinion from the panelists (Copeland, 1976).

Summary

Chapter III delineated the design of the study. It included how the area of research was determined, how the problems were identified, the procedure used in the preparation of the study, and the conduct of the research.

After the researcher determined the area of interest and identified the problem, the researcher utilized a variety of methods relative to literature review and consultation with authorities to determine the appropriateness of the research topic and the best research procedure for the study.

A three round Delphi technique was used to conduct the study. The procedure was validated as being representative of the Delphi Technique. It consisted of seven Delphi panels with five members each. The panels were: technology education professionals, industrialists/ business leaders, futurists, historians of technology, philosophers of technology, anthropologists of technology, and philosophers of education. An expert representing each panel identified ten Delphi panelists from a list compiled from a review of literature and from recommendations of people interviewed. From this list, five Delphi panelists were randomly selected for each panel. The panelists were contacted and ask to serve in the study.

The first round Delphi instrument was open-ended. The second round gained consensus of opinion, based on the first round data, using a Q sort method. The third round Delphi instrument gained consensus of opinion from each panel using a Q sort method. The responses of each Delphi round was compiled by the researcher.

Following the third round content analysis, an Equal Apearing Interval Scale was used to assign a numeric value to each response. The responses were ranked from highest to lowest.

Chapter IV will report the results of the study.

CHAPTER IV. RESULTS OF THE STUDY

Introduction

The purpose of this study was to identify what will be the key descriptors of a definition for technology and what will be the appropriate curricular organizers for the study of technology. A three round Delphi and Thurstone and Chave Equal Appearing Interval Scale technique were used as the appropriate research procedure for this study.

Delphi I

The Delphi I (Appendix A) instrument was mailed to the 35 selected panelists. Twenty-six panelists returned the instrument by the deadline. The nine panelists not returning the Delphi I instrument were dropped from the study. All nine panelists either telephoned or wrote to explain their reasons for not being able to complete the study. Copies of letters of those who dropped out are shown in Appendix B. Once all Delphi I instruments were received, the researcher conducted a content analysis on all items for each research question. Redundant responses were consolidated through the analysis, thus forming the Delphi II instrument.

Delphi II

The Delphi II instrument (Appendix C) was mailed to the 26 panelists who completed the Delphi I instrument. This instrument asked each panelist to Q sort the items for each research question using the Thurstone and Chave Equal Appearing Interval Scale. Twenty-five panelists returned the instrument by the deadline. One participant resigned due to his busy work schedule. Once all Delphi II instruments were received, a scale value and Q value were calculated for each item by group and cumulative of all groups. Q sort cards, containing the item's scale value, were made for each research question. This comprised the Delphi III instrument.

Delphi III

The Delphi III instrument (Appendix D) was mailed to the 25 panelists. Again, the panelists were asked to Q sort the items for each research question. Twenty four returned the instrument by the deadline, with the exception of one. A scale value and Q value were calculated by panel and cumulative for all groups for each item of a research question. Items with a scale value at or above the 80th centile (Copeland, 1976) representing those items in which consensus of opinion was reached by the panelists. Items were ranked from highest to lowest scale by panel and cumulative for each item of a research question.

Delphi Panels

Seven Delphi panels, initially consisting of five members each, were used to conduct the study. The panels were: (1) technology educators, (2) philosophers of education, (3) philosophers of technology, (4) historians of technology, (5) anthropologists of technology, (6) futurists, and (7) industrialists/business leaders. The participant breakdown, by panel, is summarized in Table 1. It should be noted that even though the numbers for a particular panel are small, the total number of panelists fall within recommended standards for a Delphi panel (Dalkey, 1967, p. 11).

Table 1

Summary Table - Participant Breakdown

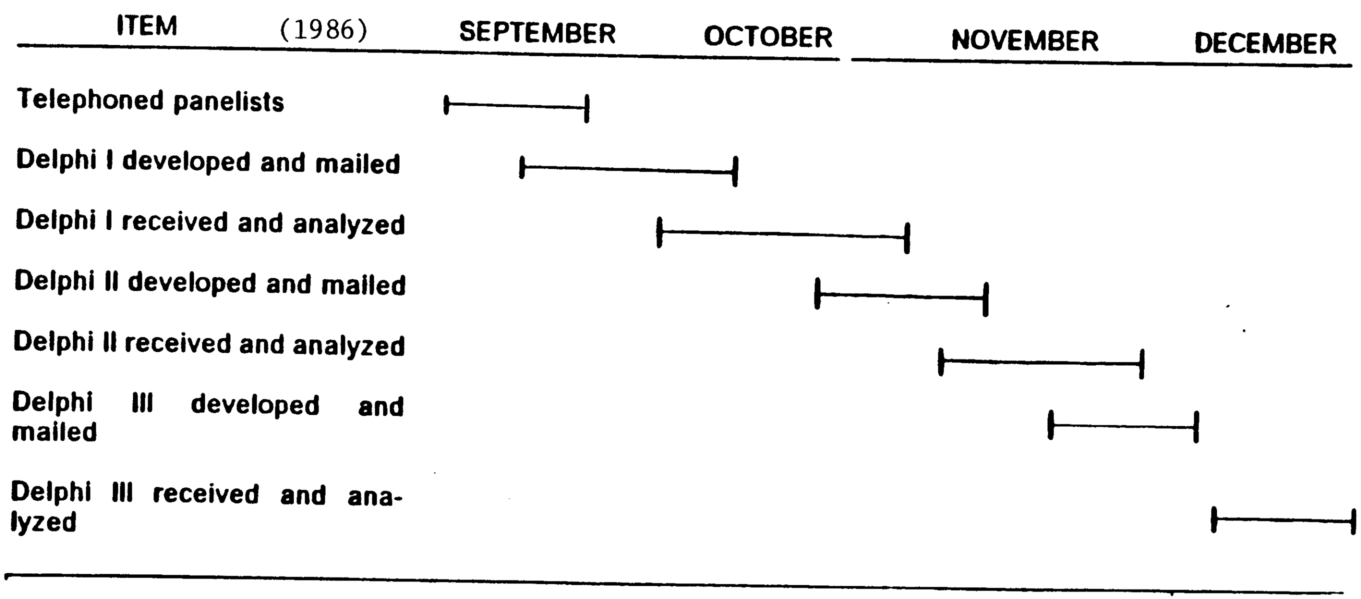
Panel	Delphi I	Delphi II	Delphi III
Technology educators	5	5	5
Philosophers of education	5	2	2
Philosophers of technology	5	3	2
Historians of technology	5	4	4
Anthropologists of technology	5	4	4
Futurists	5	4	4
Industrialists/Business leaders	5	4	4
Total (N)	35	26	25

Time Frame

The timing of mailings for each Delphi instrument was crucial to the success of the study. It should be noted that a longer period of time was used since this was an international study. The time frame used for this study is presented in Table 2:

Table 2

Time Frame



Delphi I

The responses for Delphi I are summarized in Appendix E. It should be noted that the responses are included in the appendices instead of the chapter because of their extensiveness. Duplicated items are included in the tables. After the content analysis was conducted for the key descriptor of a definition for technology items, the items were narrowed to 133 items. The items for the appropriate curricular organizers for the study of technology were consolidated to 88 items, after the content analysis was conducted.

Key Descriptors of a Definition for Technology

The technology educators identified items that included human activity, a study and process, skills: designing, making things, using technological products, problem solving, invention, and innovation. The philosophers of education listed such descriptive items as applications, techniques, procedures, psychoergonomics, problem solving, and knowledge based. The philosophers of technology emphasized such key descriptors as devices, purposeful activity, instruments, skills and techniques, products and services, and use of artifacts.

The historians of technology identified such key descriptors of a definition for technology as a study of man-made artifacts, an area of human activity, purposeful, human manipulation of the material world, employing techniques, applied through tools or machines, and works with materials. The anthropologists of technology described technology with such items as key to human evolution in the future, diffusion of adoption often involves modification, played an important role in the emergence of *Homo sapiens*, changes through time, varies across cultures, and support systems. Futurists included such key descriptors of a definition for technology as body of knowledge, concerns the practical world, broader than engineering, innovation, method, and technique. The industrialists/business leaders identified such key descriptors as applied science, technological literacy, a class of materials, application of knowledge, application of tools, and application of skills.

Curricular Organizers for the Study of Technology

When identifying curricular organizers for the study of technology, technology educators listed such items as the process of technology, the systems of technology, the elements of technology, the types of technology, problem solving, and process organizers. Among the curricular organizers identified by the philosophers of education were science, construction, manufacturing, engineering, communication, and agriculture. The philosophers of technology identified such curricular organizers as limits of technology, appropriate technology, philosophy of technology, values in technology, social factors, and organizational structures.

The historians of technology listed such curricular organizers as public policy of technology, technology assessment, technology literacy elements, economics, sociology, and social studies of technology. Among the curricular organizers for the study of technology identified by the anthropologists of technology were technology transfer, humanities, demography, technology and organization theory, archeology, and anthropology. Futurists identified such curricular organizers as food and water, weapons and defense, space, design and innovation, shelter, and telecommunicaions. Industrialists/business leaders listed such curricular organizers as transportation, the theory of technology, social sciences, biological sciences, physical sciences, and information processing.

Most groups identified innovation, invention, some type of human activity, problem solving, and some relationship to values as both important for key descriptors of a definition for technology and for curricular organizers for the study of technology. Most groups also emphasized processes, systems, and methods over specific types of technology or content. Among the processes identified were engineering, manufacturing, constructing, communicating, transporting, the process of technology, and process organizers. Examples of systems were adaptive system, systems of technology, and fields of endeavor. Methods included problem solving, inventing, and employing techniques. The futurists, historians of technology, and the philosophers of education tended to be more narrowly focused to specific content or descriptors, while the opposite is true of the other panels.

Delphi II

The findings of Delphi II are presented in Tables 3 - 17, by panel and cumulative for all groups, for each research question. The tables are ranked from highest to lowest scale value. The 80th centile represents the breakpoint for which consensus of opinion was reached after the second round for an item. For the key descriptors of a definition for technology the following scale values for the 80th centile are technology educators - 10.25, philosophers of education - 9.75, philosophers of technology - 8.38, historians of technology - 9.50, anthropologists of technology - 9.58, futurists - 9.41, industrialists/business leaders - 9.17, and cumulative - 9.59.

Key Descriptors of a Definition for Technology

The data are presented in Tables 3 - 9, by group, for the key descriptors of a definition for technology. Technology educators (Table 3) reached a consensus on 12 key descriptors of a definition for technology. Invention, innovation, problem solving, resources (materials, energy, concepts, physical, personal, and intellectual), creative, a purpose (social, personal, economic values, context, and assessments), and knowledge based received the highest consensus for the group. Even though these items were considered equally favorable by scale value, it should be noted that there was a large dispersion of opinion among the descriptors, with the exception of invention and innovation.

The philosophers of education (Table 4) reached a consensus of opinion on four key descriptors of a definition for technology. It should be noted that all panelists agreed that a body of knowledge was the most favorable descriptor of a definition for technology, as is indicated by its scale and Q values.

The philosophers of technology (Table 5) only agreed on two key descriptors after the second round. The Q values for both items tend to indicate a slight dispersion on consensus of opinion.

The historians of technology (Table 6) agreed with 14 key descriptors of a definition for technology. While only two items were considered equally the most favorable, there was a wide range of opinion on all 14 key descriptors gaining a consensus of opinion for this round.

The anthropologists of technology (Table 7) reached a consensus of opinion on eight key descriptors. They viewed the key descriptor, a variable to explain cross-cultural differences in social organizations, beliefs, and culture, as the most favorable.

Futurists (Table 8) reached a consensus of opinion on 11 key descriptors of a definition for technology. The key descriptors, frequently generates hidden consequences and side effects and innovation were considered the equally the most favorable by the futurists.

Industrialists/business leaders (Table 9) agreed with 12 key descriptors of a definition for technology. However, only two of the 12 key descriptors were considered most favorable, as is indicated by their scale values. It should be noted, however, that there was a wider range of opinion relative to the key descriptor, extension of human potential than with the key descriptor applied knowledge.

Table 3

Delphi II

Key Descriptors of a Definition for Technology

- Technology Educators (N = 5)

Item	Scale Value	Q Value
Invention	10.67	0.95
Innovation	10.67	0.95
Problem solving	10.67	2.33
Resources -materials -energy -concept -physical -personal -intellectual	10.67	2.33
Creative	10.67	2.33
A purpose -social -personal -economic values -context -assessments	10.67	4.33
Knowledge based	10.67	5.33
Used to solve problems or or create opportunities	10.25	1.13
Decision making	10.25	1.15
Technology-society relations	10.25	3.13
Technological literacy	10.25	4.13
Human capabilities	10.25	4.13

Table 4

Delphi II

Key Descriptors of a Definition for Technology

- Philosophers of Education (N = 2)

Item	Scale Value	Q Value
Body of knowledge	11.00	0.50
Maximizes human potential	10.50	1.00
Played an important role in the emergence of *Homo sapiens*	10.50	1.00
Extends human capabilities -physical -social -intellectual	10.50	1.00

Table 5

Delphi II

Key Descriptors of a Definition for Technology

- Philosophers of Technology (N = 3)

	Scale	Q
Played an important role in the emergence of *Homo sapiens*	9.50	1.00
Linked to industrial productivity and economic growth	8.50	1.00

Table 6

Delphi II

Key Descriptors of a Definition for Technology

- Historians of Technology (N = 4)

Item	Scale Value	Q Value
Purposeful, human manipulation of the material world	10.88	3.67
An area of human activity	10.88	4.67
Skills and techniques	10.50	4.50
Varies across cultures	10.00	2.00
Body of knowledge	10.00	2.00
Purposeful activity	9.50	2.00
A function of cultural values	9.50	2.00
Extends human capabilities -physical -social -intellectual	9.50	2.00
Changes through time	9.50	3.00
Goal driven	9.50	3.50
Processes	9.50	4.00
"Know-how"	9.50	4.00
Concerns the practical world	9.50	4.00
A process	9.50	4.50

Table 7

Delphi II

Key Descriptors of a Definition for Technology

- Anthropologists of Technology (N = 4)

Item	Scale Value	Q Value
A variable to explain cross-cultural differences in social organization, beliefs, and culture	10.88	1.67
Innovation	10.50	2.50
Has social, economic, political and environmental impacts	10.00	0.50
Manifest and latent functions	10.00	2.00
A system of tools, knowledge, and behaviors associated with the exploitation of environments	10.00	3.00
Evolution	10.00	4.00
Technological literacy	10.00	4.00
Changes through time	9.88	0.67

Table 8

Delphi II

Key Descriptors of a Definition for Technology

- Futurists (N = 4)

Item	Scale Value	Q Value
Frequently generates hidden consequences and side effects	10.50	1.50
Innovation	10.50	1.50
Extends human capabilities -physical -social -intellectual	10.17	0.62
May be material (physical device or product) or social (method of doing or making)	10.00	6.00
Application of knowledge	9.88	2.67
Closely linked to science but not simply applied science	9.88	3.67
"Know-how"	9.88	7.67
Invention	9.50	1.50
Purposeful, human manipulation of the material world	9.50	1.50
Central to advance of Western Civilization	9.50	7.00
Creative	9.50	9.00
Body of knowledge	9.50	9.00

Table 9

Delphi II

Key Descriptors of a Definition for Technology

- Industrialists/Business Leaders (N = 4)

Item	Scale Value	Q Value
Applied knowledge	10.50	1.50
Extension of human potential	10.50	6.50
Application of skills	10.00	4.00
Applied science	10.00	4.00
A process -change -individual -corporate -design -creative -systematic	9.50	2.00
System of knowledge of and transformation of environmental resourses	9.50	3.00
Closely linked to science but not simply applied science	9.50	3.50
Processes	9.50	4.50
Purposeful, human manipulation of the material world	9.50	4.50
Problem solving	9.50	5.50
Maximizes human potential	9.50	6.50
A system of tools, knowledge, and behaviors associated with the exploitation of environments	9.50	6.50

Curricular Organizers for the Study of Technology

The 80th centile scale values for the appropriate curricular organizers for the study of technology are technology educators - 9.50, philosophers of education - 9.65, philosophers of technology - 9.10, historians of technology - 9.44, anthropologists of technology - 9.29, futurists - 10.13, industrialists/business leaders - 10.29, and cumulative - 9.83. The findings of the curricular organizers for the study of technology are indicated in Tables 10 - 15, with only those items that reached consensus. Technology educators (Table 10) agreed with 11 items as curricular organizers for the study of technology. Process organizers (creativity, enterprise, systems, inventions, and problem solving) were considered the most favorable by this group. However, it should be noted that the Q values for the 11 items gaining consensus show a slight difference of opinion relative to consensus.

Only two curricular organizers for the study of technology reached a consensus of opinion by the philosophers of education (Table 11). Research and development was viewed as the most favorable curricular organizer by this group.

It should be noted that the two philosophers of technology did not reach a consensus of opinion on any items relative to the appropriate curricular organizers for the study of technology.

The historians of technology (Table 12) agreed with 11 items as appropriate curricular organizers for the study of technology. However, only two organizers, public policy of technology and values in technology were considered equally the most favorable items. The Q values indicate some difference of opinion relative to the 11 items gaining a consensus of opinion.

Eleven curricular organizers reached a consensus of opinion after the second round by the anthropologists of technology (Table 13). It should be noted, however, that of the two items gaining the highest consensus of opinion, there was a large range of opinion as is indicated by their Q values.

The futurists (Table 14) only agreed on two items as appropriate curricular organizers for the study of technology after Delphi II. The Q value for design and innovation tended to show a fairly close range of opinion relative to consensus, while the converse appears to be true of process organizers.

The industrialists/business leaders (Table 15) also agreed with problem solving as the most favorable curricular organizer. Like the other groups, design and innovation ranked high with this panel. However, it should be noted that the Q values represent some difference of opinion on items with the industrialists/business leaders. For example, the Q value for telecommunications (7.50) is extremely higher than the other Q values for this group.

Table 10

Delphi II

Curricular Organizers for the Study of Technology

- Technology Educators (N = 5)

Item	Scale Value	Q Value
Process organizers -creativity -enterprise -systems -inventions -problem solving	10.88	0.44
Capability -investigating -inventing -implementing -evaluating	10.67	1.20
The process of technology	10.67	1.33
Problem solving	10.67	5.33
Values in technology	10.25	3.13
Design and innovation	10.00	2.13
Theory of technology	9.75	3.25
Elements of technology -appropriateness -levels (high-intermediate-low) -transfer -assessment -impacts -time line (past-present-future) -tools -materials -processes -information -human -etc.	9.75	8.63
Energy	9.67	2.33
Technology literacy elements	9.67	3.33
Materials	9.67	3.95

Table 11

Delphi II

Curricular Organizers for the Study of Technology

- Philosophers of Education (N = 2)

Item	Scale Value	Q Value
Research and development	10.50	1.00
Telecommunications	10.00	0.50

Table 12

Delphi II

Curricular Organizers for the Study of Technology

- Historians of Technology (N = 4)

Item	Scale Value	Q Value
Public policy of technology	10.00	1.00
Values in technology	10.00	1.00
Technology transfer	9.88	1.67
Limits of technology	9.50	1.50
Technology and environment	9.50	1.50
Ethical implications of	9.50	1.50
Social studies of technology	9.50	1.50
Technology assessment	9.50	1.50
Appropriate technology	9.50	2.50
Technology and organization change	9.50	3.00
The process of technology	9.50	3.50

Table 13

Delphi II

Curricular Organizers for the Study of Technology

- Anthropologists of Technology (N = 4)

Item	Scale Value	Q Value
Energy	10.50	4.50
Technology and organizational change	10.50	9.50
Technology and environment	10.17	0.62
Problem solving	10.00	4.00
Resources -knowledge (generalized concepts) -skills (intellectual and spiritual) -personal qualities -motivation -resourcefulness	10.00	8.00
Philosophy of technology	9.88	0.67
Social factors	9.88	0.67
Theory of technology	9.50	3.50
Awareness of implications and potential of technology -health -food -communication -production -control	9.50	7.00
Elements of technology -appropriateness -levels (high-intermediate-low) -transfer -assessment -impacts -time line (past-present-future) -tools	9.50	9.00

Table 13 continued

-materials -processes -information -human -etc.		
Definition of technology	9.50	9.50

Table 14

Delphi II

Curricular Organizers for the Study of Technology

- Futurists (N = 4)

Item	Scale Value	Q Value
Design and innovation	10.50	1.00
Process organizers -creativity -enterprise -systems -inventions -problem solving	10.50	7.50

Table 15

Delphi II

Curricular Organizers for the Study of Technology

- Industrialists/Business Leaders (N = 4)

Item	Scale Value	Q Value
Problem solving	10.88	0.67
Design and innovation	10.88	2.67
The systems of technology (input-procress-output) -communication -production -transportation -exploration -development -controlling -etc.	10.88	4.67
The fields of endeavor -communication -manufacturing -construction -transportation -medicine -agriculture -etc.	10.88	4.67
Energy	10.50	1.00
Transportation	10.50	1.50
Process organizers -creativity -enterprise -systems -inventions -problem solving	10.50	2.50
Communication	10.50	2.50
The process of technology	10.50	2.50
Telecommunications	10.50	7.50

Cumulative

A cumulative look at all the groups in Delphi II relative to the key descriptors of a definition of technology and the appropriate curricular organizers for the study of technology are presented in Tables 16 and 17. It should be noted that all items are listed, regardless of the item reaching a consensus of opinion at the 80th centile or not. The purpose of these tables is to show how each item compared in relation to all other items for a research question. The 80th centile scale value for the key descriptors of a definition for technology was 9.59, while 9.83 was the 80th centile value for the curricular organizers for the study of technology.

Only three key descriptors gained a consensus of opinion after Delphi II, with innovation reaching the highest agreement. The Q values for the three items appears to indicate some dispersion of opinion on most items. It should be noted that the lower the Q value the closer in agreement the participants were for an item.

Only two items reached a consensus of opinion after the second round for the curricular organizers for the study of technology. Like the key descriptors of a definition for technology, the Q values tend to suggest some range of opinion for most items.

Based on the findings in Tables 16 - 17, the panelists tended to view more global descriptors of a definition for technology and the appropriate curricular organizers for the study of technology than specific, technical, or narrow focused items. For example, waste disposal, gadgetry, a class of materials, and expert systems are not considered very favorable as key descriptors of a definition for technology. This trend is true with regard to the curricular organizers for the study of technology. The more favorable curricular organizers reflect processes, concepts, and methods, instead of specific technical content. Interestingly, the traditional industrial arts or industrial technology curricular organizers of manufacturing, construction, transportation, and communication did not reach a consensus of opinion by the panelists.

Table 16

Delphi II

Key Descriptors of a Definition for Technology

- Cumulative (N = 26)

Item	Scale Value	Q Value
Innovation	*9.80	3.23
Purposeful, human manipulation of the material world	*9.63	2.55
Creative	*9.63	5.06
Extends human capabilities -physical -social -intellectual	9.40	2.54
Invention	9.25	3.53
Application of knowledge	9.20	3.70
Closely linked to science but not simply applied science	9.14	3.82
Problem solving	9.13	3.26
A process	9.00	3.62
"Know-how"	8.92	4.92
Extension of human potential	8.88	3.65
May be material (physical device or product) or social (method of doing or making)	8.86	3.81
Impacts on economic, social and political dynamics	8.83	3.72
A process -change -individual -corporate -design -creative -systematic	8.81	3.30
Played an important role in the emergence of *Homo sapiens*	8.80	4.10

Table 16 continued

System of knowledge of use and transformation of environmental resources	8.75	3.23
Body of knowledge	8.75	5.28
Processes	8.72	3.38
Used to solve problems or create opportunities	8.67	4.09
A system of tools, knowledge, and behaviors associated with the exploitation of environments	8.63	4.21
Technological innovation (the appearance and uptake of new technologies) is a "stage process" phenomenom, including invention, development, deployment and implementation	8.60	3.56
Applied knowledge	8.60	3.63
Decision making	8.60	3.64
Has social, economic, political and environmental impacts	8.40	2.98
Skills and techniques	8.38	3.55
Mutual influence between technology and society	8.33	4.21
Changes through time	8.25	4.27
Frequently generates hidden consequences and side effects	8.25	4.29
Resources (materials, energy, concept, physical, personal, and intellectual)	8.25	4.40
Linked to industrial productivity and economic growth	8.20	2.28
A purpose -social -personal -economic values -context -assessments	8.13	4.13
A function of cultural values	8.13	4.17
Gives people new powers and responsibilities	8.08	2.67

Table 16 continued

Rational approaches	8.00	3.34
Human-machine relations	8.00	3.50
Technology-society relations	8.00	3.53
Central of advance of Western Civilization	8.00	4.17
Shaped by design of engineering	8.00	5.35
Developing the human-made world	7.92	2.67
An area of human activity	7.88	4.42
Application of tools	7.88	4.51
An inherently value laden social process	7.80	3.33
Goal driven	7.80	3.44
Focused on the control or manipulation of nature	7.80	3.50
Applied through tools or machines	7.80	4.79
Technological literacy	7.75	4.12
Varies across cultures	7.75	4.54
Governed by laws of nature	7.75	4.75
A core component to all indigenous cultural systems	7.67	3.19
Knowledge of applications	7.63	2.41
Key to human evolution in the future	7.63	2.88
Is interposed between humans and use of the environment	7.63	3.04
Method	7.63	3.40
Skills: designing, making things, using technological products	7.63	3.50
Application of skills	7.63	3.70
Adaptive system	7.63	4.06
Workings, works of humans	7.60	3.57
Technology management	7.56	3.28

Table 16 continued

Purposeful activity	7.48	3.86
Human purpose	7.38	4.11
Operates in natural and "built" environment	7.33	2.66
Designed operations	7.20	2.25
Diffusion or adoption often involves modification	7.14	3.02
Maximizes human potential	7.13	4.49
Manifest and latent functions	7.00	3.19
Concerns the practical world	7.00	4.02
Changes in form and/or matter, energy and information	6.92	2.99
Evolution	6.88	5.13
Information content	6.75	3.82
Employing techniques	6.75	4.06
Knowledge based	6.75	5.50
Design is the basic approach	6.75	5.88
Functionality	6.72	2.12
Techno-political-economic groups and attitudes	6.67	2.90
Social invention	6.67	3.83
Often known by its embodiments (products)	6.67	4.67
Similarly, related to but *not* equivalent to engineering	6.67	4.81
Using power	6.63	2.92
Manufacture	6.44	1.80
Products and services	6.43	1.78
Applied science	6.42	4.63
Biological technology	6.38	3.86
Maximizes benefits of technology to people	6.38	4.61
Advancing civilization	6.38	4.69

Table 16 continued

Product -thing -system -organization	6.38	5.44
A variable to explain cross-cultural differences in social organization, beliefs, and culture	6.33	7.29
Servant to society	6.30	4.16
Use of artifacts	6.25	2.96
Idea about objects	6.25	4.36
Works with materials	6.20	3.13
A product of scientific research	6.20	5.25
A function of environmental knowledge	6.19	2.50
Cuts across time periods	6.19	3.63
Basic principles	6.14	2.81
Human capabilities	6.14	5.78
Achievements	6.11	3.93
Constraints -economic -material	6.00	3.50
A strategy for extracting energy from physical environment	6.00	3.88
Artificial intelligence	6.00	4.82
Technical ideologies	6.00	4.94
Hardware	6.00	5.12
Impacts	6.00	5.88
Theoretical aspects	5.92	2.86
Converges social structures	5.88	3.70
Historical	5.88	4.72
Software	5.86	3.77
Safety	5.81	3.82

Table 16 continued

Materials and objects as physical forms that "do" something	5.80	3.44
A school subject	5.78	3.04
A study of exploitation of the physical environment	5.75	4.27
Instruments	5.75	2.83
Physical technology	5.71	4.44
Devices	5.67	3.50
Support systems	5.67	3.50
Realizing the potential of the universe	5.67	5.57
Social technology	5.63	5.67
State of the art	5.60	1.32
Technical interest groups	5.58	2.77
A study	5.58	5.50
Little understood by most users	5.25	4.84
Regulation	5.00	3.73
Institutional technology	5.00	3.82
Consumption	4.88	3.33
High (modern) vs low (pre-modern or Third World) technologies	4.75	6.75
Assessment	4.67	4.13
A class of materials	4.58	4.08
Expert systems	4.40	5.10
Management or mismanagement	4.38	4.27
The system that determines population size and density	4.33	3.80
Uncovering science	4.28	2.75
Batch size vs efficiency (customized mass production)	3.31	3.35

Table 16 continued

Gadgetry	3.60	2.84
Waste disposal	3.67	3.87

* represents items reaching consensus of opinionat the 80th centile

Table 17

Delphi II

Curricular Organizers for the Study of Technology

- Cumulative (N = 26)

Item	Scale Value	Q Value
Process organizers -creativity -enterprise -systems -inventions -problem solving	*10.20	3.30
Problem solving	*10.08	3.63
Values in technology	9.80	1.06
Energy	9.65	2.70
Design and innovation	9.60	2.18
Research and development	9.42	2.30
The process of technology	9.33	3.77
Theory of technology	9.33	3.59
Capability -investigating -inventing -implementing -evaluating	9.25	4.45
Technology and environment	9.13	2.49
Elements of technology -appropriateness -levels (high-intermediate-low) -transfer -assessment -impacts -time line (past-present-future) -tools -materials -processes -information -human -etc.	9.13	2.89
Limit of technology	9.13	2.93

Table 17 continued

Technology assessment	9.11	1.80
Philosophy of technology	9.08	2.46
Communication	9.00	1.73
Awareness of implications and potential of technology -health -food -communication -production -control	9.00	2.47
Ethical implications of	8.92	3.80
Transportation	8.71	2.77
Food and water	8.69	3.89
Social studies of technology	8.67	2.78
Information processing	8.60	2.62
Public policy of technology	8.55	1.83
Technology transfer	8.42	2.40
Automation	8.41	3.07
Technology and living environment (in and around the home)	8.38	2.74
Physical technologies -civil -mechanical -electrical -chemical -aerospace -biomedical -forest and forest products -etc.	8.38	3.08
Computers	8.25	3.07
Materials	8.25	3.63

Table 17 continued

The systems of technology (input-process-output) -communication -production -transportation -exploration -development -controlling -etc.	8.25	4.05
Resources -knowledge (generalized concepts) -skills (intellectual and personal) -personal qualities -motivation -resourcefulness	8.25	4.66
Appropriate technology	8.13	3.90
History of technology	8.13	4.33
Electronic/Electro-optical	8.08	2.55
Cultural organizers -communication -production -transportation	8.00	3.19
Telecommunications	8.00	3.30
Technology and organizational change	8.00	3.70
Cognitive organizers -aeronautical -biological -chemical -electrical -information -management -mechanical -etc.	8.00	3.73
Technology and work and profession	7.94	2.95
Service technologies -automated -etc.	7.88	3.28

Table 17 continued

The fields of endeavor -communication -manufacturing -construction -transportation -medicine -agriculture -etc.	7.88	3.92
Product organizers -materials -processes -tools	7.88	3.94
Construction	7.80	2.99
Manufacturing	7.80	3.14
Power	7.80	3.27
The engineering disciplines -mechanical -electrical -civil -etc.	7.75	2.70
Technology literacy elements	7.75	3.08
Social factors	7.75	3.50
Organizational structures	7.63	3.50
Instrumentation	7.60	2.44
Industry	7.60	2.54
Applied physics	7.60	3.03
Micro technology	7.60	3.13
Environmental	7.42	2.88
Weapons and defense	7.40	3.72
Physical sciences	7.38	3.48
Types of technology -physical -biological -information	7.33	3.81

Table 17 continued

Space	7.20	2.50
Science	7.20	3.82
Applied chemistry	7.14	2.19
Applied biology	7.13	2.89
Agriculture	7.08	2.49
Economics	7.00	2.56
Telematics	7.00	4.37
Shelter	6.88	2.34
Technology and leisure time	6.81	2.50
Media technology	6.80	2.90
Social sciences	6.80	5.52
Mechanics	6.75	3.34
Humanities	6.67	7.14
Biological sciences	6.60	3.75
Musical technology	6.38	3.86
Ceramics	6.31	2.16
Agronomy	6.31	2.16
Definition of technology	6.29	5.31
Technique	6.25	3.52
Constituencies for and against	6.25	4.49
Funding	6.13	3.32
Standards/measurement	6.07	2.91
Progression	6.00	5.50
Cultural anthropology	6.00	6.49
Pharmacology	5.92	2.32
Geology	5.88	3.94

Table 17 continued

Demography	5.75	4.13
Sociology	5.75	4.36
Archeology	5.67	4.19
Anthropological technology	5.40	4.95
Psychology	5.33	3.86
Art technology	5.33	5.66

* represents items reaching consensus of opinion at the 80th centile

Delphi III

•

The results of Delphi III are summarized, by panel and cumulative for all groups, in Tables 18 - 32. The items in the tables are ranked from highest to lowest scale value. The 80th centile represents the breakpoint for which an item reached a consensus of opinion. The 80th centile scale value for the key descriptors of a definition for technology are technology educators - 9.50, philosophers of education - 9.43, philosophers of technology - 8.50, historians of technology - 9.67, anthropologists of technology - 9.40, futurists - 9.23, industrialists/business leaders - 9.58, and cumulative - 9.27.

Key Descriptors of a Definition for Technology

The findings are presented, by group, for the key descriptors of a definition for technology are found in Tables 18 - 32. The technology educators (Table 18) reached a consensus of opinion on 16 key descriptors. The key descriptor, creative, was viewed as the most favorable item, with almost total agreement. The Q values for the eight most favorable items tend to indicate very little disagreement on the ranking of these curricular organizers.

The philosophers of education (Table 19) agreed with 17 key descriptors of a definition for technology. There was total agreement on applied knowledge as the most favorable descriptor. Applied knowledge was also viewed as the most favorable descriptor for technology in Delphi II by the philosophers of education, however, the Delphi III showed stronger support for the item. There was also close agreement on most of the descriptors gaining consensus by the philosophers of education, as is indicated by their Q values.

Six items reached agreement by the philosophers of technology (Table 20). Although all six items reached a consensus, their Q values tend to suggest some difference of opinion within items. There was more agreement on the key descriptors, central to the advance of Western Civilization, than on the other items that reached consensus. The scale and Q values for the other items suggests that the philosophers viewed these items as being of equal importance.

The historians of technology (Table 21) reached a consensus of opinion on seven key descriptors of a definition for technology. It should be noted that all Q values appear to indicate some difference of opinion on reaching a consensus of opinion on an item.

The anthropologists of technology (Table 22) agreed with 17 items relative to key descriptors of a definition for technology. They viewed innovation as the most favorable item, but its Q value tends to indicate some difference of agreement on the descriptor.

Futurists (Table 23) agreed with 13 key descriptors of a definition for technology. They agreed that innovation and frequently generates hidden consequences and side effects as the most favorable items. Interestingly, these two descriptors were the two most favorable key descriptors for the futurists in Delphi II. However, they received stronger support in the Delphi III. The Q values tended to suggest more agreement toward innovation than frequently generates hidden consequences and side effects as a key descriptor.

Eight items gained a consensus of opinion by the industrialists/business leaders (Table 24). Problem solving was considered the most favorable descriptor, but its Q value tends to indicate some disagreement among panelists.

Table 18

Delphi III

Key Descriptors of a Definition for Technology

- Technology Educators (N = 5)

Item	Scale Value	Q Value
Creative	10.88	0.44
Invention	10.88	0.44
Innovation	10.67	0.95
A process	10.50	1.67
Problem solving	10.33	0.96
Purposeful, human manipulation of the material world	10.25	5.13
Extension of human potential	10.00	0.67
Decision making	10.00	0.67
A process - change - individual - corporate - design - creative - systematic	10.00	1.13
Technology-society relations	10.00	1.75
Maximizes human potential	9.75	2.63
Closely linked to science but simply applied science	9.75	2.63
Extends human capabilities - physical - social - intellectual	9.75	2.63
Used to solve problems or create opportunities	9.75	3.25
Body of knowledge	9.75	7.63
Application of knowledge	9.50	3.13

Table 19

Delphi III

Key Descriptors of a Definition for Technology

- Philosophers of Education (N = 2)

Item	Scale Value	Q Value
Applied knowledge	11.00	0.50
Maximizes human potential	10.50	1.00
Creative	10.00	0.50
Used to solve problems and create opportunities	10.00	0.50
Extends human capabilities - physical - social - intellectual	10.00	0.50
A process -change -individual -corporate -design -creative -systematic	10.00	0.50
Social invention	10.00	1.00
Application of knowledge	9.50	1.00
Technological literacy	9.50	1.00
Developing the human-made world	9.50	1.00
Extension of human potential	9.50	1.00
Problem solving	9.50	1.00
Theoretical aspects	9.50	1.00
System of knowledge of use and transformation of of environmental resources	9.50	1.00

Table 19 continued

Key to human evolution in the future	9.50	1.00
An inherently value laden social process	9.50	2.00
Advancing civilization	9.50	2.00

Table 20

Delphi III

Key Descriptors of a Definition for Technology

- Philosophers of Technology (N = 2)

Item	Scale Value	Q Value
Central to the advance of Western Civilization	8.50	2.00
Used to solve problems and create opportunities	8.50	3.00
Gives people new powers and responsibilities	8.50	3.00
Purposeful, human manipulation of the material world	8.50	3.00
Extends human capabilities - physical - social - intellectual	8.50	3.00
Played an important role in the emergence of Homo sapiens	8.50	3.00

Table 21

Delphi III

Key Descriptors of a Definition for Technology

- Historians of Technology (N = 4)

Item	Scale Value	Q Value
Purposeful, human manipulation of the material world	10.50	2.50
Body of knowledge	10.00	2.00
A process	10.00	3.00
Mutual influence between technology and society	10.00	3.00
A process - change - individual - corporate - design - creative -systematic	10.00	3.00
A system of tools, knowledge, and behaviors associated with the exploitation of environments	10.00	5.00
Skills and techniques	9.83	1.67

Table 22

Delphi III

Key Descriptors of a Definition for Technology

- Anthropologists of Technology (N = 4)

Item	Scale Value	Q Value
Innovation	10.88	3.67
Extension of human potential	10.50	1.50
Invention	10.50	2.50
Played an important role in the emergence of *Homo sapiens*	10.50	3.50
Frequently generates hidden consequences and side effects	10.50	5.50
Creative	10.50	9.50
Closely linked to science but not simply applied science	10.50	9.50
Has social, economic, political, and environmental impacts	10.17	0.62
A core component to all indigenous cultural systems	10.00	0.50
Is interposed between humans and use of the environment	10.00	1.00
Changes through time	9.50	1.50
Linked to industrial productivity and economic growth	9.50	1.50
Purposeful, human manipulation of the material world	9.50	2.50
A process -change -individual -corporate -design -creative -systematic	9.50	3.00

Table 22 continued

A system of tools, knowledge, and behaviors associated with the exploitation of environments	9.50	3.50
A variable to explain cross-cultural differences in social organization, beliefs, and culture	9.50	3.50
Technological innovation (the appearance and uptake of new technologies) is a "stage-process" phenomenon, including invention, development, deployment, and implementation	9.50	4.50

Table 23

Delphi III

Key Descriptors of a Definition for Technology

- Futurists (N = 4)

Item	Scale Value	Q Value
Innovation	10.50	1.50
Frequently generates hidden consequences and side effects	10.50	4.50
Creative	10.00	0.50
Invention	10.00	1.00
Know-how	9.88	0.67
Applications of tools	9.88	1.67
Body of knowledge	9.88	3.67
Skills and techniques	9.50	1.00
Extends human capabilities -physical -social -intellectual	9.50	1.50
Application of knowledge	9.50	2.00
A system of tools, knowledge, and behaviors associated with the exploitation of environments	9.50	2.00
Purposeful, human manipulation of the material world	9.50	2.50
A process -change -individual -corporate -design -creative -systematic	9.50	4.00

Table 24

Delphi III

Key Descriptors of a Definition for Technology

- Industrialists/Business Leaders (N = 4)

Item	Scale Value	Q Value
Problem solving	10.85	2.66
Extension of human potential	10.83	0.67
Extends human capabilities -physical -social -intellectual	10.83	1.66
Used to solve problems and create opportunities	10.50	1.50
Innovation	10.00	2.00
A system of tools, knowledge, and behaviors associates with the exploitation of environments	10.00	6.50
System of knowledge of use and transformation of environmental resources	9.88	4.67
Resources -materials -energy -concept -physical -personal -intellectual	9.83	1.67

Curricular Organizers for the Study of Technology

The scale value for the 80th centile for the appropriate curricular organizers for the study of technology are technology educators - 9.10, philosophers of education - 9.67, philosophers of technology - 9.95, historians of technology - 9.50, anthropologists of technology - 9.50, futurists - 9.50, industrialists/business leaders - 10.16, and cumulative - 9.68. It should be noted that the philosophers of technology did not reach agreement on any items relative to the appropriate curricular organizers for the study of technology.

The curricular organizers for the study of technology (Tables 25 - 30) represent the findings, by group. Technology educators (Table 25) agreed with 16 items as curricular organizers for the study of technology. There was total agreement on problem solving as being the most favorable curricular organizer. This supports the cumulative consensus of opinion found in the study. Design and innovation, capability, and process organizers also gained strong support by the technology educators. However, the Q value for process organizers appears to show less support for it as an appropriate curricular organizer than the other items.

Four items reached agreement by the philosophers of eduaction (Table 26). They agreed that design and innovation and the philosophy of technology were equally the most favorable items as curricular organizers for the study of technology. Interestingly, all four items gaining a consensus of opinion for Delphi III did not reach consensus by this group for the Delphi II.

The historians of technology (Table 27) agreed with 11 items as curricular organizers for the study of technology. They viewed the history of technology as the most favorable curricular organizer, but its Q value suggest some difference of opinion among panelists. It should be noted that public policy of technology, the most favored item by this group in Delphi II dropped considerably, while their number two Delphi II item stayed the same.

As in Delphi II, the two philosophers of technology did not reached a consensus of opinion on any item as being an appropriate curricular organizer for the study of technology. However, they did view social and ethic concepts favorably.

The anthropologists of technology agreed with 17 items as appropriate curricular organizers for the study of technology (Table 28). They totally agreed with problem solving as the most favorable curricular organizers for the study of technology. This supports the beliefs of the technology educator, futurists, and industrialists/business leaders. The Q values of all other items tend to suggest that there was disagreement among panelist on the importance of these items as appropriate curricular organizers for the study of technology.

The futurists (Table 29) reached a consensus on 12 items. Like the anthropologists of technology, technology educators, and industrialists/business leaders, they totally agreed with problem solving as the most important curricular organizer for the study of technology. Again, like the anthropologists of technology, there was disgreement among the panelists on reaching a consensus on the importance of an item, however, not to the extent of the anthropologists of technology.

The industrialists/business leaders reached agreement on eight items (Tables 30). They, like the technology educators, anthropologists of technology, and futurists, totally viewed problem solving as the most favorable item as an appropriate curricular organizer for the study of technology.

Table 25

Delphi III

Curricular Organizers for the Study of Technology

- Technology Educators (N = 5)

Item	Scale Value	Q Value
Problem solving	11.00	0.50
Design and innovation	10.88	1.44
Capabality -investigating -inventing -implementing -evaluating	10.88	1.44
Process organizers -creativity -enterprise -system -invention -problem solving	10.88	3.44
The process of technology	10.25	1.13
Research and development	10.25	2.13
Philosophy of technology	10.25	4.63
Values in technology	10.00	2.13
Elements of technology - appropriateness - levels (high-intermediate-low) - transfer - assessment - impacts - time line (past-present-future) - tools - materials - processes -information - information - human - etc.	9.75	1.25
Technology and environment	9.75	3.63
Limits of technology	9.75	5.63

Table 25 continued

Communication	9.33	0.96
Technology transfer	9.25	2.50
Appropriate technology	9.25	5.63
Technology assessment	9.25	6.63
The systems of technology (input-process-output) -communication -production -transportation -exploration -development -controlling -etc.	9.13	0.63

Table 26

Delphi III

Curricular Organizers for the Study of Technology

- Philosophers of Education (N = 2)

Item	Scale Value	Q Value
Design and innovation	10.50	1.00
Philosophy of technology	10.50	1.00
The process of technology	10.00	0.50
Technology literacy elements	10.00	0.50

Table 27

Delphi III

Curricular Organizers for the Study of Technology

- Historians of Technology (N = 4)

Item	Scale Value	Q Value
History of technology	10.50	2.50
Values in technology	10.00	1.00
Social studies of technology	10.00	5.00
Technology and organizational change	9.88	4.67
Technology and work and profession	9.83	1.67
Technology transfer	9.50	1.00
Research and development	9.50	1.50
Public policy of technology	9.50	2.00
Ethical implications of	9.50	2.00
Problem solving	9.50	2.00
Limits of technology	9.50	2.00

Table 28

Delphi III

Curricular Organizers for the Study of Technology

- Anthropologists of Technology (N = 4)

Item	Scale Value	Q Value
Problem solving	11.00	0.50
Process organizers -creativity -enterprise -systems -inventions -problem solving	10.88	9.67
Values in technology	10.50	4.50
Theory of technology	10.50	2.50
Energy	10.50	3.50
Elements of technology -appropriateness -levels (high-intermediate-low) -transfer -assessment -impacts -time lines (past-present-future) -tools -materials -processes -information -human	10.50	4.50
Technology assessment	10.00	1.00
Public policy of technology	10.00	1.50
Awareness of implications and potential of technology -health -food -communication -production -control	10.00	2.00
Research and development	10.00	5.50
Philosophy of technology	10.00	9.00

Table 28 continued

History of technology	9.88	0.67
Resources -knowledge (generalized concepts) -skills (intellectual and personal) -personal qualities -motivation -resourcefulness	9.88	4.67
Ethical implications of	9.50	1.50
Technology and environment	9.50	2.50
The process of technology	9.50	4.50
Design and innovation	9.50	7.00

Table 29

Delphi III

Curricular Organizers for the Study of Technology

- Futurists (N = 4)

Item	Scale Value	Q Value
Problem solving	11.00	0.50
Physical technologies - civil - mechanical - electrical - chemical - aerospace - biomedical - forest and forest products	10.00	2.00
The systems of technology (input-process-output) -communication -production -transportation -exploration -development -controlling	10.00	3.00
Technology assessment	10.00	6.00
Elements of technology -appropriateness -levels (high-intermediate-low) -transfer -assessment -impacts -time line (past-present-future) -tools -materials -processes -information -human -etc.	9.50	1.00
Awareness of implications and potential of technology -health -food -communication -production -control	9.50	1.50
Technology and environment	9.50	2.00

Table 29 continued

The fields of endeavor -communication -manufacturing -construction -transportation -medicine -agriculture -etc.	9.50	3.00
Cognitive organizers -aeronautical -biological -chemical -electrical -information -management -mechanical -etc.	9.50	3.00
The process of technology	9.50	4.00
Design and innovation	9.50	4.00
Limits of technology	9.50	4.50

Table 30

Delphi III

Curricular Organizers for the Study of Technology

- Industrialists/Business Leaders (N = 4)

Item	Scale Value	Q Value
Problem solving	11.00	0.50
Process organizers -creativity -enterprise -systems -inventions -problem solving	10.83	0.67
Capability -investigating -inventing -implementing -evaluating	10.50	1.00
Resources -knowledge (generalized concepts) -skills (intellectual) -personal skills (qualities) -motivation -resourcefulness	10.50	1.50
Research and development	10.50	2.50
Theory of technology	10.50	3.50
The systems of technology (input-process-output) - communication - production - transportation - exploration - development - controlling	10.00	1.00
Awareness of implications and potential of technology - health - food - communication - production - control	10.00	3.00

Cumulative

A breakdown as to how an item compared with all other items for its respective research question, based on the collective view of all seven panels is shown in Tables 31 and 32. The 80th centile scale value for the definition for technology was 9.27, while 9.68 was the 80th centile scale value for the appropriate curricular organizers for the study of technology. The consensus items are represented by "*" in Tables 31 and 32.

The cumulative description of the key descriptors of a definition for technology is shown in Table 31. Fourteen items, compared with only two items for Delphi II, gained a consensus of opinion for Delphi III relative to the key descriptors of a definition for technology. Innovation again reached the highest consensus of opinion, but its Q value tends to indicate some difference of opinion among groups. It should be noted that, like in Delphi II, the key descriptors tended to emphasize global items instead of specific or narrowly focused items. All items reaching a consensus for Delphi III tended to gain more support than they did in Delphi II.

The cumulative view for the appropriate curricular organizers for the study of technology are summarized in Table 32. As indicated by the table, seven items reached a consensus of opinion, compared with only two items in Delphi II. It should be noted that problem solving gained the most favorable support by the panels, as compared with process organizers for Delphi II. Awareness of the implications and potential of technology is should be subsumed under the other six consensus curricular organizers. Like in Delphi II, the curricular organizers gained agreement emphasize a conceptual organization of technology, instead of a technical content organization of technology. Again, as in Delphi II, the traditional curricular organizers of industrial arts or industrial technology (manufacturing, construction, communication, and transportation) did not reach a consensus of opinion.

Table 31

Delphi III

Key Descriptors of a Definition for Technology - Cumulative (N = 25)

Item	Scale Value	Q Value
Innovation	10.42*	2.33
Invention	10.08*	2.30
Creative	10.06*	1.89
Extends human capabilities -physical -social -intellectual	9.91*	1.93
A process -change -individual -corporate -design -creative -systematic	9.88*	2.03
Extension of human potential	9.81*	2.36
Problem solving	9.75*	2.66
Purposeful, human manipulation of the material world	9.71*	2.36
Closely linked to science but not simply applied science	9.60*	3.09
Body of knowledge	9.55*	3.48
Used to solve problems and create opportunities	9.40*	2.26
Played an important role in the emergence of *Homo sapiens*	9.33*	3.39
A system of tools, knowledge, and behaviors associated with the exploitation of environments	9.33*	3.89
Has social, economic, political, and environmental impacts	9.29*	3.05

Table 31 continued

Application of knowledge	9.18	1.94
Mutual influence between technology society	9.13	3.20
Technological innovation (the appearance and uptake of new technologies) is a "stage-process" phenomenon, including invention, development, deployment, and implementation	9.08	2.88
Processes	8.92	2.40
System of knowledge of use and transformation of environmental resources	8.92	2.68
Skills and techniques	8.88	3.13
Changes through time	8.85	3.10
Applied knowledge	8.75	2.64
Frequently generates hidden consequences and side effects	8.67	3.81
Decision making	8.67	4.05
Technology-society relations	8.67	4.19
Developing the human-made world	8.63	2.90
Gives people new powers and responsibilities	8.58	2.48
May be material (physical device or product) or social (method of doing or making)	8.58	3.17
Linked to industrial productivity and economic growth	8.57	2.96
Changes in form and/or matter, energy and information	8.56	1.80
"Know-how"	8.51	2.88
Human-machine relations	8.40	2.69
A core component to all indigenous cultural systems	8.40	3.48
Key to human evolution in the future	8.38	2.65

Table 31 continued

Resources -materials -energy -concept -physical -personal -intellectual	8.25	3.22
Impacts on economic, social, and political dynamics	8.25	9.79
Application of tools	8.14	3.02
Application of skills	8.13	2.73
Central to advance of Western Civilization	8.13	3.16
An inherently value laden social process	8.13	4.63
Knowledge of applications	8.00	2.46
A function of cultural values	8.00	3.70
Adaptive system	7.91	2.23
Applied through tools or machines	7.80	1.85
Human purpose	7.80	2.99
Varies across cultures	7.75	2.53
Is interposed between humans and use of the environment	7.75	3.02
Technology management	7.71	3.09
Rational approaches	7.67	3.21
An area of human activity	7.60	2.70
Shaped by design of engineering	7.42	3.38
Goal driven	7.40	3.25
A purpose -social -personal -economic -values -context -assessments	7.40	3.52
Governed by the laws of nature	7.38	2.51
Workings, works of humans	7.38	3.27

Table 31 continued

Skills: designing, making things, using technological products	7.38	3.29
Manifest and latent functions	7.33	2.87
Concerns the practical world	7.33	3.05
Technological literacy	7.33	4.18
Often known by its embodiments (products)	7.25	2.93
Similarly, related to, but *not* equivalent to engineering	7.00	3.63
Diffusion or adoption often involves modification	7.00	3.65
Functionality	6.92	2.30
Realizing the potential of the universe	6.92	4.28
Focused on the control or manipulation of nature	6.86	2.82
A strategy for extracting energy from physical environment	6.86	3.30
Maximizes human potential	6.80	3.04
A study of exploitation of the physical environment	6.75	4.47
Human capabilities	6.71	3.06
Advancing civilization	6.69	2.84
Constraints -economic -material	6.67	2.11
Social invention	6.63	3.95
Purposeful activity	6.60	3.20
Knowledge base	6.58	2.01
Idea about objects	6.43	2.09
Employing techniques	6.43	3.34
Support systems	6.42	2.52
Method	6.42	3.21
Evolution	6.40	2.73

Table 31 continued

Designed operations	6.40	2.96
Hardware	6.40	3.57
Maximizes benefits of technology to people	6.40	4.83
Works with materials	6.38	2.74
Operates in natural and "built" environment	6.38	4.13
A variable to explain cross-cultural differences in social organization, beliefs, and culture	6.33	3.19
Servant to society	6.29	3.33
Theoretical aspects	6.25	3.20
A product of scientific research	6.20	3.11
Cuts across time periods	6.20	3.13
Techno-political-economic groups and attitudes	6.20	3.66
Information content	6.14	2.62
Manufacture	6.13	5.71
Achievements	6.11	2.05
Basic principles	6.11	2.29
Use of artifacts	6.00	2.74
Product (thing, system, organization)	6.00	4.08
Design is the basic approach	6.00	4.38
Biological technology	5.92	2.67
Artifical intelligence	5.92	3.61
Using power	5.80	2.87
Social technology	5.80	3.63
Physical technology	5.75	2.16
Converges social structures	5.75	3.16
Products and services	5.75	3.63
Historical	5.75	4.13

Table 31 continued

Impacts	5.75	4.18
Materials and objects as physical forms that "do" something	5.00	4.16
Software	5.60	1.96
Devices	5.58	3.09
Little understood by most users	5.58	6.15
State of the art	5.56	4.28
A school subject	5.55	2.71
Institutional technology	5.33	2.76
Instruments	5.25	2.91
A function of environmental knowledge	5.13	3.29
A study	5.00	4.16
High (modern) vs low (pre-modern or Third World) technologies	4.63	3.34
Regulation	4.42	3.95
Safety	4.40	3.34
Technical ideologies	4.40	4.02
Technical interest groups	4.25	3.19
Expert systems	4.20	3.28
Consumption	4.00	2.99
Management or mismanagement	4.00	3.28
Assessment	3.88	2.89
Uncovering science	3.67	3.19
Waste disposal	3.67	5.25
Batch size vs efficiency customized mass production)	3.08	3.83

Table 31 continued

Gadgetry	2.92	4.32
A class of materials	2.75	3.79

* represents consensus of opinion at the 80th centile

Table 32

Delphi III

Curricular Organizers for the Study of Technology

- Cumulative (N = 25)

Item	Scale Value	Q Value
Problem solving	10.76*	1.50
Process organizers -creativity -enterprise -systems -inventions -problem solving	10.61*	3.30
Values in technology	10.00*	2.13
The process of technology	9.91*	2.25
Design and innovation	9.80*	2.26
Research and development	9.76*	2.22
Awareness of implications and potential of technology -health -food -communication -production -control	9.69*	2.55
Philosophy of technology	9.67	2.73
Capability -investigating -inventing -implementing -evaluating	9.63	3.75
Limits of technology	9.60	3.09
Elements of technology -appropriateness -levels (high-intermediate-low) -transfer -assessment -impacts -time line (past-present-future) -tools -materials	9.58	2.48

Table 32 continued

-processes -information -human -etc.		
Technology assessment	9.38	3.01
Theory of technology	9.33	2.84
History of technology	9.20	2.37
Technology and environment	9.20	2.37
Resources -knowledge (generalized concepts) -skills (intellectual and personal) -personal qualities -motovation -resourcefulness	9.20	4.16
Technology transfer	9.14	2.34
Ethical implications of	9.08	2.32
Energy	9.00	3.21
The systems of technology (input-process-output) -communication -production -transportation -exploration -development -controlling -etc.	8.94	2.21
Communication	8.89	2.05
Telecommunications	8.89	2.48
Cognitive organizers -aeronautical -biological -chemical -electrical -information -management -mechanical -etc.	8.89	2.73

Table 32 continued

Physical technologies -civil -mechanical -electrical -chemical -aerospace -biomedical -forest and forest products -etc.	8.80	2.34
Public policy of technology	8.75	3.27
Automation	8.69	2.32
Transportation	8.67	3.11
Appropriate technology	8.42	3.07
Information processing	8.42	3.19
Social studies of technology	8.40	4.88
Computers	8.38	2.33
Technology and Organizational Change	8.38	3.46
The engineering disciplines -mechanical -electrical -civil -etc.	8.25	2.89
Definition of technology		
Cultural organizers -communication -production -transportation	8.20	2.23
Technology and living environment (in and around the home)	8.00	2.24
Technology and work and profession	7.92	3.23
Types of technology -physical -biological -information	7.80	2.90

Table 32 continued

Product organizers -materials -processes -tools	7.75	2.73
Social factors	7.75	3.50
The fields of endeavor -communication -manufacturing -construction -transportation -medicine -agriculture -etc.	7.67	3.32
Power	7.60	4.19
Micro technology	7.58	3.94
Space	7.57	2.58
Electronic/Electro-optical	7.40	2.64
Organizational structures	7.38	3.04
Agriculture	7.38	3.27
Construction	7.33	3.09
Service technology -automated -etc.		
Weapons and defense	7.33	4.21
Manufacturing	7.25	2.89
Environmental	7.25	2.98
Technology and leisure time	7.25	4.27
Technology literacy elements	7.13	2.49
Shelter	7.13	3.20
Industry	7.00	3.04
Telematics	6.88	2.54
Instrumentation	6.80	2.80
Physical sciences	6.80	3.04

Table 32 continued

Food and water	6.67	2.97
Media technology	6.67	3.49
Science	6.63	2.37
Applied chemistry	6.60	3.25
Economics	6.40	3.13
Funding	6.38	3.65
Technique	6.38	4.90
Biological sciences	6.80	3.14
Applied physics	6.19	2.73
Mechanics	6.14	2.33
Social sciences	6.13	3.81
Humanities	6.00	6.57
Progression	5.94	2.88
Archeology	5.92	4.40
Agronomy	5.80	3.44
Applied biology	5.72	3.71
Musical technology	5.67	3.63
Sociology	5.63	3.70
Geology	5.63	4.95
Demography	5.60	3.88
Constituencies for and against	5.40	3.33
Ceramic	5.40	3.45
Standards/measurements	5.38	3.48

Table 32 continued

Cultural anthropology	5.25	4.63
Pharmacology	5.13	3.63
Art technology	5.00	4.88
Anthropological technology	4.75	2.91

* represents items reaching consensus at the 80th centile

Consensus of Opinion

The results of this study are based on the research questions defined for the study. Conclusions are presented under two headings: (1) key descriptors of a definition for technology and (2) curricular organizers for the study of technology.

Key Descriptors of a Definition for Technology

Fourteen items (Table 33) reached a consensus of opinion relative to what will be the key descriptors of a definition for technology from the panels of experts. It appeared from the data that the definition will be described in terms of statements that emphasize concepts and processes. The data also appeared to indicate a strong emphasis on the relationship between humans, their capabilities and potential as they interface with the social, economic, political, and environmental impacts of their culture and their future.

According to the data, there tended to be greater emphasis on innovation, invention, creativity and problem solving than on hardware and software. It also appeared from the data that the definition for technology will be described in more holistic terms than narrowly focused to a specific type of technology.

The technology educators viewed the item creative as the most important descriptor of a definition for technology, followed by invention and innovation respectively. It appeared from the data a strong emphasis on a global description of technology. The data indicated relatively strong support for a problem solving, a decision making, and a process approach. Little emphasis was placed on narrowly focused descriptors.

The data appeared to indicate that philosophers of education place a greater emphasis on describing technology relative to the human and how technology affects the human. Based on the data, they described technology as applied knowledge, technology as a means for maximizing human potential, technology used to solve problems and create opportunities, and technology as a process. It appeared from the data that philosophers of education were less likely to describe technology as closely related to science or engineering, as a class of materials, or the system that determines population size or density.

It appeared from the data that the philosophers of technology had a more difficult time reaching a consensus of opinion on the items for the key descriptors of a definition for technology than did the other panels. However, like the philosophers of education, they tended to be concerned with describing technology in the terms of its effects on the advancement of humans and how its helps humans function in the environment by extending their capabilities.

Based on the data, the historians of technology were more concerned with describing technology skills and techniques that help humans manipulate their environment. It appeared from the data that historians of technology believed that technology is a process and has a definite body of knowledge. The data also suggest that they were less inclined to describe technology as uncovering science, or that system that determines population size and density.

Like the technology educators, the anthropologists of technology placed greater emphasis on innovation, extension of human potential, invention and creative among their key descriptors of a definition for technology. The data also appeared to indicate that they described technology as a core component to all indigenous cultural systems. Conversely, the data appear to indicate that anthropologists of technology were less likely to describe technology as technology management, a class of materials, or as advancing civilization.

The data appeared to show that futurists, like other panels, described technology in the terms of innovation, creative, invention, and a body of knowledge. However, unlike most groups, futurists tended to place a high value on the application of tools as a key descriptor of a definition for technology. The data also tended to indicate that futurists were less inclined to describe technology in a narrow scope.

Unlike other panels, the industrialists/business leaders tended to place a high value on describing technology as an approach to solving problems and creating opportunities. The data also suggested that they contend that technology extends human potential and human capabilities. The data also appear to indicate that industrialists/business leaders were less likely to support the notion that technology should be described as a class of materials or as skills or technological products.

Table 33

Consensus Summary Table

-Key Descriptors of a Definition for Technology (N = 25)

Delphi I	Delphi II	Delphi III
A process		
Often known by its embodiments (products)		
Workings, work of humans		
Application of knowledge		
Application of tools		
Servant to society		
Governed by laws of nature		
Shaped by design of engineering		
State of the art		
Batch size vs efficiency (customized mass production)		
Information content		
Creative	X	X
Technology management		
Expert systems		
Artifical intelligence		
Functionality		
A product of scientific resaerch		
Used to solve problems or create opportunities		X
Frequently generates hidden consequences and side effects		
Little understood by most users		
Gives people new powers and responsibilities		

Table 33 continued

Impacts on economic, social and political dynamics

Central to advance of Western Civilization

A study

Materials and objects as physical forms that "do" something

Idea about objects

Manifest and latent functions

Manufacture

Evolution

Human-machine relations

Support systems

Instruments

Gadgetry

Devices

Processes

Products and services

Skills and techniques

Knowledge based

Management or mismanagement

Consumption

Assessment

Regulation

Rational approaches

Technical interest groups

Table 33 continued

Techno-political-economic groups and attitudes		
Technical ideologies		
High (modern) vs low (pre modern or Third World) technologies		
Purposeful, human manipulation of the material world	X	X
Works with materials		
Using power		
Applied through tools or machines		
Employing techniques		
A school subject		
Applied science		
Technological literacy		
Maximizes human potential		
Maximizes benefits of technology to people		
Uncovering science		
Invention		X
Innovation	X	X
Use of artifacts		
Advancing civilization		
Developing the human-made world		
Realizing the potential of the universe		
Safety		
Adaptive system		
Extension of human potential		X
"Know-how"		
Operates in natural and "built" environment		
Goal driven		

Table 33 continued

Applied knowledge	
Knowledge of applications	
Problem solving	X
Human purpose	
Technology-society relations	
Human capabilities	
Decision making	
A class of materials	
Historical	
Theoretical aspects	
Basic principles	
Waste disposal	
Body of knowledge	X
Concerns the practical world	
Design is the basic approach	
Purposeful activity	
Method	
Social invention	
Physical technology	
Social technology	
Biological technology	
Institutional technology	
Impacts	
Designed operations	
Software	

Table 33 continued

Hardware	
System of knowledge of use and transformation of environmental resources	
Changes through time	
Varies across cultures	
Is interposed between humans and use of the environment	
Is a function of cultural values	
Is a function of environmental knowledge	
A study of exploitation of the physical environment	
A strategy for extracting energy from physical environment	
A system of tools, knowledge, and behaviors associated with the exploitation of environments	X
A variable to explain cross-cultural differences in social organization, beliefs, and culture	
The system that determines population size and density	
An area of human activity	
Closely linked to science but not simply applied science Similarly, related to, but not equivalent to engineering	X
An inherently value laden social process	
Has social, economic, political and environmental impacts	X
Cuts across time periods	
Focused on the control or manipulation of nature	
Changes in form and/or matter, energy and information	

Table 33 continued

Skills: designing, making things, using technological products	
Mutual influence between technology and society	
May be material (physical device or product) or social (method of doing or making)	
Key to human evolution in the future	
Played an important role in the emergence of *Homo sapiens*	X
Extends human capabilities -physical -social -intellectual	X
A core component to all indigenous cultural systems	
Diffusion or adoption often involves modification	
Technological innovation (the appearance and uptake of new technologies) is a "stage-process" phenomenon, including invention, development, deployment, and implementation	
Converges social structures	
Linked to industrial productivity and economic growth	
A process -change -individual -corporate -design -creative -systematic	X
A purpose -social values -personal values -economic values -context -assessments	
Resources -materials -energy -concept	

Table 33 continued

-physical
-personal
-intellectual
Constraints
-economic
-material
Achievements
Product
-thing
-system
-organization

X represents items reaching consensus of opinion for a Delphi round

Curricular Organizers for the Study of Technology

Collectively, the data (Table 34) tended to indicate that the curricular organizers were based on concepts and methods, instead of content. The data showed that there was also almost total consensus on problem solving as the most important curricular organizer. Four out of seven groups ranked problem solving as the most appropriate curricular organizer. The data also appeared to indicate that process organizers that are composed of the integration of problem solving and creativity with systems, enterprise, and inventions, values in technology, the process of technology, design and innovation, and research and development were also highly appropriate curricular organizers for the study of technology. Although awareness of implications and potential of technology also reached a consensus of opinion by the panelists, it should be noted that it is subsumed under the aforementioned curricular organizers.

From a review of the data, technology educators believed that problem solving was the most favorable curricular organizer for the study of technology. The data also appeared to show that technology educators tended to agree on all the curricular organizers that gained a consensus of opinion by the panelists. The data tended to indicate that technology educators were less inclined to support subject matter organizers as appropriate curricular organizers for the study of technology.

The data suggested that the study of technology were organized around concept and process organizers for the philosophers of education. It appeared from the data that they highly favored design and innovation as an appropriate curricular organizer for the study of technology. The data also tended to show that the philosophy of technology, the process of technology, and technology literacy elements were very favorable as appropriate curricular organizers. Again, the data indicated that the philosophers of education will tended not to favor specific content organizers as being appropriate curricular organizers for the study of technology.

Based on the data, it appeared that the philosophers of technology were more inclined to organize the study of technology around ethical and social concepts. They tended to place a greater emphasis on the limits of technology, appropriate technology, the history of technology, ethical implications of technology, the social studies of technology, and the philosophy of technology as being very favorable curricular organizers for the study of technology. On the other hand, they tended to viewed organizing technology around work, leisure time and progression as less favorable.

The data appeared to indicate that historians of technology, like the philosophers of technology, tended to organize the study of technology around social and ethical concepts. The data tended to indicate that they highly favored the history of technology, technology and organizational change as being very favorable curricular organizers for the study of technology. Conversely, the data appeard to show that historians of technology tended not to be willing to organize the study of technology as a content structure.

Like the technology educators, the data appeared to show that anthropologists of technology viewed problem solving and process organizers as the most favorable curricular organizers for the study of technology. Values in technology, the theory of technology, the elements of technology, and research and development also tended to be highly favorable, according to the data. The data tended to indicate that anthropologists of technology were less likely to organize the study of technology around content.

The data appeared to show that futurists agree with the majority that problem solving will be the most favorable curricular organizer for the study of technology. However, unlike other panels, the futurists highly favored physical technologies and the systems of technology as being very favorable curricular organizers. Like the other panels, the data tended to show that futurists will be less inclined to organize the study of technology as content.

The data tend to indicate that industrialists/business leaders agreed with the technology educators and the anthropologists of technology that problem solving and process organizers were the most favorable curricular organizers for the study of technology. Like all other groups, the data appear to support the notion that industrialists/business leaders were less likely to organize the study of technology as content.

Table 34

Consensus Summary Table

-Curricular Organizers for the Study of Technology (N = 25)

Delphi I	Delphi II	Delphi III
The systems of technology (input-process-output) -communication -production -transportation -exploration -development -controlling -etc.		
The process of technology		X
The engineering disciplines -mechanical -electrical -civil -etc.		
The elements of technology -appropriateness -levels (high-intermediate-low) -transfer -assessment -impact -time line (past-present-future) -tools -materials -processes -information -human -etc.		
Media technology		
Limits of technology		
Technology and Organizational Change		
The fields of endeavor -communication -manufacturing -transportation -medicine -agriculture -etc.		

Table 34 continued

Types of technology		
-physical		
-biological		
-information		
Standards/measurement		
Technology and work and profession		
Technology and leisure time		
Technology and living environment (in and around the home)		
Technology and environment		
Cognitive organizers		
-aeronautics		
-biological		
-chemical		
-electrical		
-information		
-management		
-mechanical		
-etc.		
Musical technology		
Technology transfer		
Cultural organizers		
-communication		
-production		
-transportation		
Process organizers	X	X
-creativity		
-enterprise		
-systems		
-inventions		
-problem solving		
Product organizers		
-materials		
-processes		
-tools		
Science		
Construction		

Table 34 continued

Communication

Agriculture

Manufacturing

Social factors

Organizational structures

Constituencies for and against

Physical technologies
-civil
-mechanical
-electrical
-chemical
-aerospace
-biomedical
-forest and forest products
-etc.

Art technology

Instrumentation

Theory of technology

Service technologies
-automated
-etc.

Appropriate technology

Information processing

Transportation

Energy

Physical sciences

Biological sciences

Social sciences

History of technology

Food and water

Weapons and defense

Table 34 continued

Shelter	
Space	
Design and innovation	X
Applied chemistry	
Applied physics	
Mechanics	
Computers	
Definition of technology	
Telematics	
Telecommunications	
Applied biology	
Ceramic	
Materials	
Geology	
Agronomy	
Pharmacology	
Electronic/Electro-optical	
Automation	
Environmental	
Funding	
Archeology	
Micro technology	
Ethical implications of	
Cultural anthropology	
Economics	
Sociology	

Table 34 continued

Humanities		
Social studies of technology		
Demography		
Psychology		
Philosophy of technology		
Technology assessment		
Problem solving	X	X
Progression		
Resources		
-knowledge (generalized concepts)		
-skills (intellectual and personal)		
-personal qualities		
-motivation		
-resourcefulness		
Awareness of implications and potential of technology		X
-health		
-food		
-communication		
-production		
-control		
Capability		
-investigating		
-inventing		
-implementing		
-evaluating		
Public policy of technology		
Industry		
Technique		
Anthropological technology		
Technology literacy elements		
Power		
Research and development		X
Values in technology		X

X represents items reaching consensus of opinion for a Delphi round

Summary

The results and findings of thestudy were reported in Chapter IV. study. It presented the participant breakdown and the time frame for the study. The three Delphi rounds were also reported by group and cumulative. A comparison of consensus reached for each research question was reported. Fourteen items gained consensus for the key descriptors of a definition for technology, while seven items reached a consensus of opinion for the curricular organizers for the study of technology.

The conclusions and implications of the study will be presented in Chapter V.

CHAPTER V. CONCLUSIONS AND IMPLICATIONS

The study of technology is very complex and one which has been confused and misunderstood. With technology advancing exponentially, there are only speculations as to what the technology of tomorrow will be. Therefore, it is important to study and identify key descriptors of a definition of technology and the appropriate curricular organizers for the study of technology. By doing this, one of the glaring ironies of modern education can be eliminated, that is, that schools try to prepare students to live in a time that does not yet exist by concentrating their studies on a time that has ceased to exist (Combs, 1985, p. 96).

This chapter contains a restatement of the problem, research procedures, conclusions and implications, a comparison of the research findings with current literature, and recommendations for further study.

Restatement of the Problem

The purpose of this study was to identify key descriptors of a definition for technology and the appropriate curricular organizers for the study of technology. A three round Delphi technique was used to conduct the study after a thorough review of literature was completed and panels of experts were identified for each of the seven groups used in the study of technology.

The goals of the study focused on the following two research questions:

1. Looking into the future, what will be the key descriptors for a definition for technology, and
2. Looking into the future, what will be the appropriate curricular organizers for the study of technology?

Research Procedures

In this study a series of opinions were gathered to determine what will be the key descriptors of a definition for technology and appropriate curricular organizers for the study of technology. Seven panels of five members each were intially selected and asked to participate in the study. The panelists were composed of international educational experts in the area of technology and curriculum (Appendix F).

Delphi I

The Delphi I instrument (Appendix A) was mailed to 35 selected participants. The panels of experts were asked to complete the open-ended instrument for each research question with concise statements or lists. The instrument was divided into two sections: (1) Looking into the future, what will be the key descriptors of a definition for technology, and (2) Looking into the future, what will be the appropriate curricular organizers for the study of technology? A content analysis was conducted on all responses for each research question to edit and synthesize the items into the Delphi II instrument. The research question regarding the key descriptors of a definition for technology contained 133 items, while the research question for the appropriate curricular organizers for the study of technology contained 88 items.

Delphi II

The Delphi II instrument (Appendix C) was mailed to the 26 panelists who completed the Delphi I instrument. Each panelist was asked to Q sort the items under each research question using the method of equal appearing intervals. Once all questionnaires were received, a scale value and Q value were calculated for all items for each research question by group. A cumulative list was also prepared. One panelist withdrew from the study due to his work schedule. A Delphi III instrument was developed that included the scale value for each item for a research question.

Delphi III

The Delphi III instrument (Appendix D) was mailed to the remaining 25 panelists. Again, they were asked to Q sort the items under each research question using the method of equal appearing intervals. Once all questionnaires were received, a scale value and Q value were calculated for each item of a research question by group. A cumulative list was also prepared. Items for each items of a research question were then ranked based on scale value from highest to lowest by group and cumulative. For an item to have reached a consensus of opinion, its scale value had to be equal to or greater than that of the 80th centile. The results were mailed to the 25 panelists who completed all three rounds of the study.

Final Mailing

The results of the study were mailed to the 25 panelists who completed the study. The mailing included a letter, the final results, and a list of the panels of experts.

Conclusions

The conclusions of this study are based on the research questions defined for the study. Conclusions are presented under two headings: (1) key descriptors of a definition for technology and (2) curricular organizers for the study of technology.

Key Descriptors of a Definition for Technology

Fourteen items (Table 35) reached a consensus of opinion relative to what will be the key descriptors of a definition for technology from the panels of experts. It appeared from the data that the definition will be described in terms of statements that emphasize concepts and processes. A strong emphasis was placed on the relationships between humans, their capabilities and potential as they interface with the social, economic, political and environmental impacts of their culture and their future. There was greater emphasis on innovation, invention, creativity and problem solving than on hardware and software. The definition for technology will be described in more holistic terms than narrowly focused to a specific type of technology.

The technology educators viewed the item creative as the most important descriptor of a definition for technology, followed by invention and innovation respectively. The data indicated a strong emphasis on a holistic description of technology. Also there was relatively strong support for a problem solving, a decision making, and a process approach. Little emphasis was placed on narrowly focused descriptors.

The philosophers of education placed a greater emphasis on describing technology based upon the human and how technology affects the human. They described technology as applied knowledge, technology as a means for maximizing human potential, technology used to solve problems and create opportunities, and technology as a process. Philosophers of education were less likely to describe technology as closely related to science or engineering, as a class of materials, or the system that determines population size or density.

The philosophers of technology had a more difficult time reaching a consensus of opinion on the items for the key descriptors of a definition for technology than did the other panels. However, like the philosophers of education they tended to be concerned with describing technology in the terms of its effects on the advancement of humans and how its helps humans function in the environment by extending their capabilities.

Table 35

Summary Consensus

Key Descriptors of a Definition for Technology (In rank order, N = 25)

Key Descriptor
Innovation
Invention
Creative
Extends human capabilities (physical, social, and intellectual)
A process (change, individual, corporate, design, creative, and systematic)
Extension of human potential
Problem solving
Purposeful, human manipulation of the material world
Closely linked to science but not simply applied science
Body of knowledge
Used to solve problems and create opportunities
Played an important role in the emergence of *Homo sapiens*
A system of tools, knowledge, and behaviors associated with the exploitation of environments
Has social, economic, political, and environmental impacts

The historians of technology were more concerned with describing technology skills and techniques that help humans manipulate their environment. They believed that technology is a process and has a definite body of knowledge. Historians of technology were less inclined to describe technology as uncovering science, or a system that determines population size and density.

Like the technology educators, the anthropologists of technology placed greater emphasis on innovation, extension of human potential, invention and creative among their key descriptors of a definition for technology. They described technology as a core component to all indigenous cultural systems. Conversely, the data tended to indicate that anthropologists of technology were less likely to describe technology as technology management, a class of materials, or as advancing civilization.

The data appeared to show that futurists, like other panels, described technology in the terms of innovation, creative, invention, and a body of knowledge. However, unlike most groups, futurists tended to place a high value on the application of tools as a key descriptor of a definition for technology. Also futurists were less inclined to describe technology in a narrow scope.

Unlike other panels, the industrialists/business leaders tended to place a high value on describing technology as an approach to solving problems and creating opportunities. They contend that technology extends human potential and human capabilities. Also industrialists/business leaders were less likely to support the notion that technology should be described as a class of materials or as skills or technological products.

Curricular Organizers for the Study of Technology

Collectively, the data (Table 36) indicated that the curricular organizers were based on concepts and methods, instead of content. There was also almost total consensus on problem solving as the most important curricular organizer. Four out of seven groups ranked problem solving as the most appropriate curricular organizer. Process organizers, that are composed of the integration of problem solving and creativity with systems, enterprise, and inventions, values in technology, the process of technology, design and innovation, and research and development were also highly appropriate curricular organizers for the study of technology. Although awareness of implications and potential of technology also reached a consensus of opinion by the panelists, it should be noted that it is subsumed under the aforementioned curricular organizers. From a review of the data, technology educators believed that problem solving is the most favorable curricular organizer for the study of technology. Technology educators tended to agree on all the curricular organizers that gained a consensus of opinion by the panelists. Also technology educators were less inclined to support content organizers as appropriate curricular organizers for the study of technology.

The philosophers of education indicated that the study of technology was organized around concept and process organizers. It appeared from the data that they highly favored design and innovation as an appropriate curricular organizer for the study of technology. The philosophy of technology, the process of technology, and technology literacy elements were very favorable as appropriate curricular organizers to them. The philosophers of education tended not to favor specific content organizers as being appropriate curricular organizers for the study of technology.

Based on the data, it appeared that the philosophers of technology were more inclined to organize the study of technology around ethical and social concepts. They tended to place a greater emphasis on the limits of technology, appropriate technology, the history of technology, ethical implications of technology, the social studies of technology, and the philosophy of technology as being very favorable curricular organizers for the study of technology. On the other hand, they viewed organizing technology around work, leisure time and progression as less favorable.

Historians of technology, like the philosophers of technology were inclined to organize the study of technology around social and ethical concepts. They highly favored the history of technology, technology and organizational change as being very favorable curricular organizers for the study of technology.

Table 36

Summary Consensus

Curricular Organizers for the Study of Technology (In rank order, N = 25)

Curricular Organizer
Problem solving
Process organizers (creativity, enterprise, systems, inventions, and problem solving)
Values in technology
The process of technology
Design and innovation
Research and development
Awareness of implications and potential of technology (health, food, communication, production, and control)

Conversely, historians of technology tended to be unwilling to organize the study of technology as a content structure.

Like the technology educators, anthropologists of technology viewed problem solving and process organizers as the most favorable curricular organizers for the study of technology. Values in technology, the theory of technology, the elements of technology, and research and development also were highly favorable, according to the data. Anthropologists of technology were less likely to organize the study of technology around content.

Futurists agreed with the majority that problem solving will be the most favorable curricular organizer for the study of technology. However, unlike other panels, the futurists highly favored physical technologies and the systems of technology as being very favorable curricular organizers. Like the other panels, the data tended to show that futurists were less inclined to organize the study of technology as content.

Industrialists/business leaders agreed with the technology educators and the anthropologists of technology that problem solving and process organizers were the most favorable curricular organizers for the study of technology. Like all other groups, the data appeared to support the notion that industrialists/business leaders will be less likely to organize the study of technology as content.

Therefore, the following conclusions can be drawn from the study, based on the two research questions studied:

1. The definition for technology should be described in terms of innovation, invention, process, a body of knowledge, a process, creativity, problem solving, extending human potential and capablities, implying social-cultural values and impacts.
2. The appropriate curricular organizers for the study of technology should be organized around processes, concepts, and methods. Problem solving, process organizers, values in technology, the process of technology, design and innovation, and research and development should be implemented as the appropriate curricular organizers for the study

of technology. Awareness of the implications and potential of technology should be subsumed in the aforementioned curricular organizers.

Implications

The conclusions drawn in this study impact greatly on the future curriculum direction for the study of technology. More specifically, the conclusions imply that the traditional four organizational clusters for the study of technology (manufacturing, construction, communication, and transportation) should be discarded and be replaced with a conceptual organizational structure. This argument is also supported by the key descriptors of a definition for technology. Therefore, distinct implications may be drawn for the key descriptors of a definition for technology and the curricular organizers for the study of technology.

Key Descriptors of a Definition for Technology

The key descriptors of a definition for technology that reached a consensus of opinion indicate that technology should be defined in a broad based sense, not one dimensional, material, or subject oriented. Rather, the key descriptors imply the concepts and processes that reflect a global description of technology. Strong emphasis should be placed on relationships between humans, their capabilities and potential as they interface with the social, economic, political and environmental impacts of their culture and their future.

Problem solving, innovation, invention, and creativity support the argument for an action-based or "hands-on" approach to technology. This implies problem solving as the technological process. These descriptors also indicated that the technology spectrum ranges from the past into the future.

It should be noted that traditional industry and industrial implications were de-emphasized in the key descriptors. High emphasis should be placed on an integrative systems approach that shows relationships between the individual, society, culture, and the corporate world. Also, the descriptors indicated a relationship between science and technology, not that technology is applied science.

The impact of these key descriptors of a definition for technology should influence the way technology will be studied in the future. They imply that the present definition used in the study of technology should not be used since it only defines industrial technology. Instead, these key descriptors should frame a new definition that reflects technology *in toto*.

Curricular Organizers for the Study of Technology

The curricular organizers that reached a consensus in this study parallel the key descriptors of a definition for technology contained in this study. They imply a departure from the traditional four organizers now being used for the study of technology. This should have a significant impact on how technology is studied in the future.

The conclusions drawn on the curricular organizers support the notion that the traditional curricular organizers should be discarded. They also imply that the traditional organizers should not be replaced with new content, material or subject clusters, but should be organized by concepts or processes. This supports the argument that if the study of technology is organized by content, material, or subject then the study is delimited and constricted within present knowledge. Therefore, it does not take into account the unknown technologies and their impact in the future.

The conclusions imply, like the key descriptors, that problem solving is the appropriate technological process. Also they indicate that the curricular organizers should be integrated through a systems approach. The curricular organizers infer that values, culture, and society are equally important in the study of technology. Design and innovation should become an integral part of the study of technology. This is also true of research and development.

Therefore, it can be argued that the curricular organizers that reached a consensus in this study have significant implications for future curriculum development for the study of technology. They provide an innovative organizational structure for which to prepare citizens to solve tomorrow's problems and create opportunities. The organizers imply a broad based approach to the study of technology that is not constrained by a closed framework. They also parallel the key descriptors of a definition found in this study, as well as support the current literature on the study of technology.

A Comparison of the Research Findings with Current Literature

The purpose of this section is to compare the research findings with the current literature. Numerous educational reform reports emphasize a more holistic approach to education. including the study of three basics: science, mathematics, and technology education (*Educating Americans for the 21st Century* and *High School: A Report on Secondary Education in America*). Curriculum experts, Shane (1986) and Glatthorn (1987) also support this trend of thought.

The literature review found in Chapter 2 was representative of the current literature gathered on the topic studied. It gives the historical basis and the current trends of thought relative to appropriate curricular organizers for the study of technology.

The literature gives strong support for the definition of technology to be studied. LaPorte (1986), Maley (1985), among others have called for a consensus on an operational definition of technology. Shane (1986) discussed education in a microelectronic age that has direct implications to the need of an operational definition to help education through this new age.

Educational reform reports have also impacted on the need to study and develop an operational definition for technology. Boyer (1983) called for all students to study technology, not narrowly focused, but holistic in nature. The report, *Educating Americans for the 21st Century* also emphasizes the study of technology from a broad context.

As with any curriculum its organization must parallel its definition. Such is true with the study of technology. As supported by Shane (1986), Naisbitt (1982) and other futurists, one can only speculate on what the future will be. Therefore, it is important that the curriculum be organized in such a way that will take into account the preparation of students to be able to solve the unknown variables and problems of the future. This notion is supported by Shane (1986) and Glatthorn (1987) in discussing the curriculum of tomorrow.

Again, technology educators, like LaPorte (1986), Dugger (1985), and Maley (1985) have called for the study of technology to be reorganized to reflect a more holistic approach to its study. More specifically, Squier (1985) emphasized the need to use a problem solving and critical thinking approach to the study of technology. This approach is the predominant approach for the study of technology in many countries including the United Kingdom, the Netherlands, and Australia, just to mention a few countries.

Interestingly, the data collected in this study support the aforementioned beliefs relative to the need to study a definition for technology and the appropriate curricular organizers. The data show a strong emphasis for describing the definition of technology in holistic terms. Likewise, the data placed strong support for organizing the study of technology around concepts and methods. Special emphasis should be placed on problem solving and process organizers that integrate creativity through a systems approach.

It is the researcher's belief that the literature and the data collected and analyzed in this study lend impetus to moving toward the implementation of the key descriptors of a definition for technology and the appropriate curricular organizers for the study of technology that gained consensus in this study. Therefore, the following recommendations should be considered in this implementation process.

Recommendations for Further Research

Based on the literature review and the data collected and analyzed during this study, a catalyst has been developed for further study to be conducted relative to the research findings. As a result of this study, the following recommendations are offered for consideration.

1. Replication of research studies should be an important consideration of any research topic. However, due to the attrition encountered in this study, it is recommended that larger panels be used.
2. Since the key descriptors of a definition for technology and the appropriate curricular organizers that reached a consensus of opinion are considered valid, it is recommended that they be implemented by curriculum developers for the study of technology.
3. It is recommended that a study be conducted to develop a definition based on the key descriptors of a definition for technology that achieved a consensus in this study.
4. It is recommended that separate research studies or companion research studies should be conducted on each of the curricular organizers that obtained a consensus in this study. The initial studies should concentrate on developing the rationale, structure, and taxonomies for each curricular organizer.
5. It is recommended that subsequent studies should be conducted to research and develop the content, objectives, and technology learning activities for the organizational structure.
6. It is recommended that a research study be conducted to develop a model for problem solving as the process of technology.
7. It is recommended that a three-dimensional matrix be researched and developed to support the study of technology based on the key descriptors of a definition for technology and the curricular organizers that reached a consensus of opinion in this study.
8. More international studies in the area of technology should be conducted in order that the appropriate curriculum for the study of technology could be developed to foster technological literacy and to ensure that tomorrow's problems will be better solved. Studies of this nature should include non-Western cultures.

APPENDIX A

VIRGINIA TECH

October 9, 1986

Dear

Thank you for your willingness to serve as an expert for our International Study of Curricular Organizers for the Study of Technology. As we discussed in our recent telephone conversation, you will be involved in a three round Delphi study to examine two key research questions: (1) Looking into the future, what will be the key descriptors of a definition for technology and (2) Looking into the future, what will be the appropriate curricular organizers for the study of technology?

The attached first round (Delphi I) is open-ended. The second round (Delphi II) will ask you to Q sort the results of the previous round. This will be mailed to you on October 30, 1986, with a due date of November 20, 1986. The third round (Delphi III) will again ask you to Q sort the results of the previous round. This will be mailed to you on November 25, 1986, with a due date of December 15, 1986. Once the study has been completed, you will receive a copy of the research findings.

Enclosed please find the Delphi I instrument, with its instructions, and an example. Please read the instructions carefully, complete the instrument, and return it by October 20, 1986. There is a self-addressed, stamped envelope enclosed for this purpose.

We request that you send a copy of your resume with your Delphi I response. Again, thank you for agreeing to participate in our study. We look forward to your prompt response.

Sincerely,

James L. Barnes
Research Associate
College of Education
144 Smyth Hall
Blacksburg, VA 24061

William E. Dugger, Jr.
Professor
College of Education
144 Smyth Hall
Blacksburg, VA 24061

APPENDIX A

DELPHI I

Instructions

This study is designed to inquire into "what will be" relative to the key descriptors for a definition and the curricular organizers for the study of technology. For the purposes of this study, a key descriptor is defined as a word or phrase that represents a unique element or a common element of a definition of technology. A curricular organizer is defined as a word or phrase that identifies a major category for a field of study in technology. The words or phrases must reflect the content of the field of technology, must cover the total field of technology, and must have as little overlap as possible. You will be asked to respond to two research questions: (1) Looking into the future, what will be the key descriptors of a definition for "technology" and (2) Looking into the future, what will be the appropriate curricular organizers for the study of technology?

For clarity, please review the example cited below.

Example

Key Descriptors of a Definition of Fine Arts:

- a study
- represents different historical periods
- looks at various cultures
- a method of expression
- incorporates different artistic styles and works
- relates to social and intellectual influences

Curricular Organizers of Fine Arts:

- music
- theatre
- visual arts
- dance

DELPHI I

RESEARCH QUESTION I

__Directions__: Please answer this research question completely. If more room is needed for your response, please use the back of this page or use additional paper. If additional paper is used, please mark the paper **Research Question I**

Looking into the future, what will be the key descriptors of a definition for "technology?" A key descriptor is defined as a word or phrase that represents a unique element or common element of a definition of technology.

APPENDIX A

DELPHI I

RESEARCH QUESTION II

Directions: Please answer this research question completely. If additional room is needed for your response, please use the back of this page or use additional paper. If additional paper is used, please mark the paper **Research Question II.**

Looking into the future, what will be the appropriate curricular organizers for the study of technology? A curricular organizer is defined as a word or phrase that identifies a major category of a field of study. These curricular organizers must reflect the content of the field of technology, must cover the total field of technology, and must have as litte overlap as possible.

Approximately one week ago, you were mailed a questionnaire asking you to respond to two research questions relative to what will be the key descriptors of a definition of technology and what will be the appropriate curriculum organizers for the study of technology.

This is just a reminder asking you to complete and return the questionnaire as soon as possible. If you have already done this, please disregard this notice. Thank you for your cooperation.

Sincerely,

James L. Barnes
College of Education
144 Smyth Hall
Virginia Tech
Blacksburg, VA 24061

William E. Dugger, Jr.
College of Education
144 Smyth Hall
Virginia Tech
Blacksburg, VA 24061

APPENDIX B

NOV. 1 8 REC'D

Institute for the Future
2740 Sand Hill Road Menlo Park CA 94025-7097 415-854-6322

Roy Amara
President

11 November 1986

William E. Dugger, Jr.
Professor
College of Education
Virginia Tech
144 Smyth Hall
Blacksburg, Virginia 24061

Dear Professor Dugger:

I regret to inform you that I would like to withdraw my participation from the Delphi inquiry. I'm afraid I do not have the time to do justice to the fairly elaborate and--I'm sure--worthwhile exercise you have constructed.

Again, my regrets.

Sincerely,

RA/pds

THE
GEORGE
WASHINGTON
UNIVERSITY

Department of Anthropology / Washington, D.C. 20052 / (202) 676-6075

23 October 1986

Mr. James L. Barnes
Research Associate
College of Education
Blacksburg, VA

Dear Mr. Barnes:

I Would like to withdraw from your technology project. I cannot qualify as an expert on Curricular Organizers for a study of technology--or anything close to it. My experience with technology is limited to making a material culture collection from the Turkana in Northwestern Kenya. That was 35 years ago. In the 70's I gave one seminar labelled "technology" for a museums program.

I hope that my withdrawal will not cause you too much trouble.

Sincerely,

RALPH K. LEWIS
Professor Emeritus

APPENDIX B

APPENDIX C

VIRGINIA TECH

November 6, 1986

Dear

Thank you for your prompt response to the Delphi I questionnaire. The enclosed Delphi II questionnaire will ask you to Q sort the responses for the Delphi I. Detailed directions and an example are provided to aid you in understanding how to complete the Delphi II questionnaire.

The Delphi II questionnaire is divided into two sections: (1) Looking into the future, what will be the key descriptors of a definition of technology amd (2) Looking into the future, what will be the appropriate curricular organizers for the study of technology? The information for each section is contained in a separate envelope and marked as stated above. Please remember that you are examining the responses for each section as to "what will be." Each section represents a summarization of the responses from the Delphi I questionnaire. Your contributions may not appear exactly as you submitted them for it was necessary to combine redundant responses.

Please review carefully the directions and example before beginning the Delphi II questionnaire. A Thurstone and Chave Equal Appearing Interval Continuum is also provided to aid in the completion of this questionnaire.

Your continued promptness is greatly appreciated. Please return the Delphi II questionnaire in the enclosed self-addressed, stamped envelope by November 20, 1986. As a reminder, the Delphi III questionnaire will be mailed to you on November 30, 1986. Thank you again for your valuable assistance.

Sincerely

James L. Barnes
Research Associate
College of Education
144 Smyth Hall
Blacksburg, VA 24061

William E. Dugger, Jr.
Professor
College of Education
144 Smyth Hall
Blacksburg, VA 24061

DELPHI II

DIRECTIONS

In your Delphi II packet, you will find six envelopes: (1) Research Question I, (2) Research Question II , (3) a self-addressed, stamped return envelope, (4) Q Sort Cards - Research Question I, (5) Q Sort Cards - Research Question II, and (6) Interval Cards. The Q sort cards (statements) that you will review for each research question are contained in its specified envelope. The Interval Cards make up the Thurstone and Chave Equal Appearing Interval Continuum that will be used to complete the Delphi II questionnaire.

In order to successfully complete the Delphi II questionnaire, please follow the directions below that explain the Q sort technique to be used for this round.

You have been given a set of 11 cards (A-K) in an envelope that make up the Thurstone and Chave Equal Appearing Interval Continuum. Please arrange these interval cards in order (See Figure 1).

```
  +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
  A     B     C     D     E     F     G     H     I     J     K
Unfavorable                  Neutral                     Favorable
```

Figure 1. Thurstone and Chave Equal Appearing Interval Continuum

The A interval card should be placed on the extreme left and the K interval card should be placed on the extreme right. The A interval card represents the card on which statements (Q sort cards)are to be place that seem to express the most unfavorable feelings about the research question. The K interval card represents the card on which statements (Q sort cards) are to be placed that seem to express the most favorable feelings about the research question. The F interval card represents the "neutral" or "middle" card on which statements (Q sort cards) are to be placed that express neither favorable of unfavorable feelings about the research question. The interval cards G to K represent varying degrees of increasing favorableness, while the interval cards D to A represent varying degrees of increasing unfavorableness. You are to judge the degree of favorableness or unfavorableness of feeling for each statement (Q sort cards) relative to its research question in terms of the 11 intervals represented by the continuum. After making your judgment, place the Q sort card on its appropriate interval. You may place more than one Q sort card on an interval (See Figure 2).

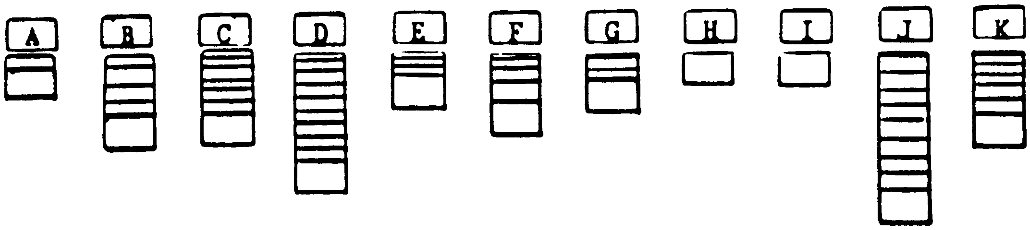


Figure 2. Example of Q sorting

When you have completed sorting all the Q sort cards for Research Question I - Looking into the future, what will be the key descriptors of a definition of technology, place one of the supplied rubber bands around the responses for each interval and place them in the Research Question I envelope. Be sure to include the interval card with its appropriate Q sort cards. Please use the same procedure for Research Question II as you used for Research Question I. Place both Research Question envelopes in the self addressed, stamped envelope. Please return your response by November 20, 1986.

A UNFAVORABLE	B
C	D
E	F NEUTRAL
G	H

I

J

K
FAVORABLE

Key Descriptors of a Definition for Technology

A process

Workings, works of humans

Application of tools

Servant to society

Often known by its embodiments

Application of knowledge

Application of skills

Governed by laws of nature

Shaped by design of engineering

Batch size vs efficiency (customized mass production)

Creative

Expert systems

State of the art

Information content

Technology management

Artifical intelligence

Functionality

A product of scientific research

Frequently generates hidden consequences and side effects

Gives people new powers and responsibilities

Safety

Used to solve problems or create opportunities

Little understood by most users

Impacts on economic, social, and political dynamics

Central to the advance of Western Civilization

Materials and objects as physical forms that "do" something

Manifest and latent functions

Evolution

A study

Ideas about objects

Manufacture

Human-machine relations

Support systems

Gadgetry

Processes

Skills and techniques

Instruments

Devices

Products and services

Knowledge based

High (modern) vs Low (pre-modern or Third World) technologies

Works with materials

Applied through tools and machines

A school subject

Purposeful, human manipulation of the material world

Using power

Employing techniques

Applied science

Technological literacy

Maximizes benefits of technology to people

Invention

Use of artifacts

Maximizes human potential

Uncovering science

Innovation

Advancing civilization

Developing the human-made world

Extension of human potential

Operates in natural and "built" environments

Realizing the potential of the universe

Adaptive systems

"Know-how"

Goal driven

Applied knowledge

Problem solving

Technology-society relations

Decision making

Knowledge of application

Human purpose

Human capabilities

A class of materials

Historical

Basic principles

Body of knowledge

Design is the basic approach

Theoretical aspects

Waste disposal

Concerns the practical world

Purposeful activity

Method

Physical technology

Biological technology

Impacts

Social invention

Social technology

Institutional technology

Designed operation

Software

System of knowledge of use and transformation of environmental resources

Varies across cultures

Is a function of cultural values

Hardware

Changes through time

Is interposed between humans and use of the environments

Is a function of environmental knowledge

A study of exploitation of the physical environment

A system of tools, knowledge, and behaviors associated with the exploitation of environments

The system that determines population size and density

Closely linked to science but not simply applied science

A strategy for extracting energy from physical environments

A variable to explain cross-cultural differences in social organization, beliefs, and culture

An area of human activity

Similarly, related to, but not equivalent to engineering

An inherently value latent social process

Cuts across time periods

Changes in form and/or matter, energy, and information

Mutual influence between technology and society

Has social, economic, political, and environmental impacts

Focused on the control or manipulation of nature

Skills: designing, making things, using technological products

May be material (physical device or product) or social (method of doing or making)

Key to human evolution in the future

Extends human capabilities (physical, social, and intellectual)

Diffusion or adoption often involves modification

Converges social structures

Played an important role in the emergence of *Homo sapiens*

A core component to all indigenous cultural systems

Technological innovation (the appearance and uptake of new technologies) is a "stage-process" phenomenom, including invention, developmnet, deployment, and implementation

Linked to industrial productivity and economic growth

A process (change, individual, corporate, design, creative, and systematic)

Resources (materials, energy, concept, physical, personal, and intellectual)

Achievements A purpose (social, personal and economic values, context, and assessments)

Constraints (economic and material)

Product (thing, system, organization)

Curricular Organizers for the Study of Technology

The process of technology

The engineering disciplines (mechanical, electrical, civil, etc.)

Elements of technology (appropriateness, levels - high, intermediate, low, transfer, assessment, impacts, time line - past, present, future, tools, materials, processes, information, human, etc.)

Standards/measurements

The systems of technology (input, process, output), construction, production, transportation, communication, exploration, development, controlling, etc.

The fields of endeavor (communication, manufacturing, construction, transportation, medicine, agriculture, etc.)

Types of technology (physical, biological, information)

Technology and work and profession

Technology and leisure time

Technology and environment

Cultural organizers (communication, production, transportation)

Product organizers (materials, processes, products, tools)

Technology and living environment (in and around the home)

Cognitive organizers (aeronautical, biological, chemical, electrical, information, management, mechanical, nautical)

Process organizers (creativity, enterprise, systems, inventions, problem solving)

Science

Media technology

Construction

Communication

Organization structures

Agricultural

Manufacturing

Social factors

Constitutencies for and against

Physical technologies (civil, mechanical, electrical, chemical, aerospace, biomedical, forest and forest products, etc.)

Instrumentation

Theory of technology

Transportation

Service technologies (automated systems. etc.)

Appropriate technology

Information processing

Energy

Physical sciences

Social sciences

Food and water

Shelter

Biological technology

History of technology

Weapons and defense

Space

Design and innovation

Applied physics

Computers

Telecommunications

Applied chemistry

Mechanics

Telematics

Geology

Applied biology

Ceramic

Materials

Automation

Agronomy

Pharacology

Electronic/Electro-optical

Micro technology

Environmental

Funding

Archeology

Economics

Resources (Knowledge - generalized concepts and operational techniques, skills - intellectual, physical, personal, personal qualities - motivation, resoursefulness)

Ethical implications of technology

Cultural anthropology

Demography

Sociology

Humanities

Social studies of technology

Public policy of technology

Psychology

Philosophy of technology

Technology assessment

Technology literacy elements

Industry

Technique

Anthropological technology

Limits of technology

Power

Research and development

Values in technology

Technology and Organizational Change

Musical technology

Problem solving

Art technology

Awareness of implications and potential of technology (health, food, communication, production, control)

Definition of technology

Technology transfer

Capability (investigating, inventing, implementing, evaluating)

Progression

Approximately one week ago, you were mailed a questionnaire asking you to respond to two research questions relative to what will be the key descriptors of a definition of technology and what will be the appropriate curriculum organizers for the study of technology.

This is just a reminder asking you to complete and return the questionnaire as soon as possible. If you have already done this, please disregard this notice. Thank you for your cooperation.

Sincerely,

James L. Barnes
College of Education
144 Smyth Hall
Virginia Tech
Blacksburg, VA 24061

William E. Dugger, Jr.
College of Education
144 Smyth Hall
Virginia Tech
Blacksburg, VA 24061

APPENDIX D

VIRGINIA TECH

November 25, 1986

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Dear

Thank you for your prompt response to the Delphi II questionnaire. The enclosed Delphi III questionnaire will ask you to Q sort the responses from the Delphi II. Detailed directions and an example are provided to aid you in understanding how to complete the Delphi III questionnaire.

The Delphi III questionnaire is divided into two sections: (1) Looking into the future, what will be the key descriptors of a definition of technology and (2) Looking into the future, what will be the appropriate curricular organizers for the study of technology? The information for each section is contained in a separate envelope and marked as stated above. Please remember that you are examining the responses for each section as to "what will be." Each section represents a summarization of the responses from the Delphi II questionnaire. Your contributions may not appear exactly as you submitted them for it was necessary to combine redundant responses.

Please review carefully the directions and example before beginning the Delphi III questionnaire. A Thurstone and Chave Equal Appearing Interval Continuum is also provided to aid in the completion of this questionnaire.

Your continued promptness is greatly appreciated. Please return the Delphi III questionnaire in the enclosed self-addressed, stamped envelope by December 15, 1986. Thank you again for your valuable assistance.

Sincerely

James L. Barnes
Research Associate
College of Education
144 Smyth Hall
Blacksburg, VA 24061

William E. Dugger, Jr.
Professor
College of Education
144 Smyth Hall
Blacksburg, VA 24061

APPENDIX D

DELPHI III

DIRECTIONS

In your Delphi III packet, you will find six envelopes: (1) Research Question I, (2) Research Question II , (3) a self-addressed, stamped return envelope, (4) Q Sort Cards - Research Question I, (5) Q Sort Cards - Research Question II, and (6) Thurstone and Chave Continuum (Interval Cards). The Q sort cards (statements) that you will review for each research question are contained in its specified envelope. The Interval Cards make up the Thurstone and Chave Equal Appearing Interval Continuum that will be used to complete the Delphi III questionnaire.

In order to successfully complete the Delphi III questionnaire, please follow the directions below that explain the Q sort technique to be used for this round.

You have been given a set of 11 cards (A-K) in an envelope that make up the Thurstone and Chave Equal Appearing Interval Continuum. Please arrange these interval cards in order (See Figure 1).

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    +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
    A     B     C     D     E     F     G     H     I     J     K
Unfavorable                     Neutral                    Favorable
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Figure 1. Thurstone and Chave Equal Appearing Interval Continuum

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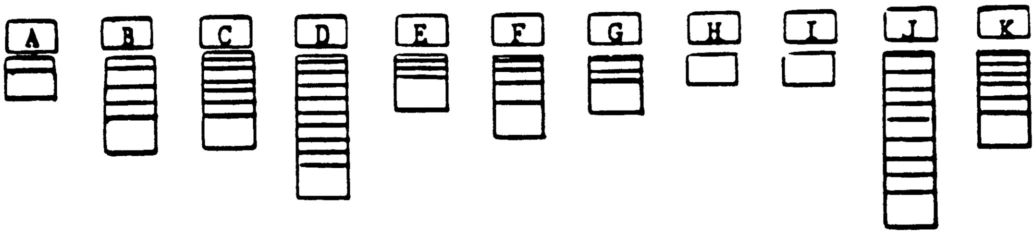

Figure 2. Example of Q sorting

When you have completed sorting all the Q sort cards for Research Question I - Looking into the future, what will be the key descriptors of a definition of technology, place one of the supplied rubber bands around the responses for each interval and place them in the Research Question I envelope. Be sure to include the interval card with its appropriate Q sort cards. Please use the same procedure for Research Question II as you used for Research Question I. Place both Research Question envelopes in the self addressed, stamped envelope. Please return your response by December 15, 1986.

A UNFAVORABLE	B
C	D
E	F NEUTRAL
G	H
I	J
K FAVORABLE	

Key Descriptors of a Definition for Technology

A process (9.00)

Workings, works of humans (7.60)

Application of tools (7.88)

Servant to society (6.30)

Often known by its embodiments (6.67)

Application of knowledge (9.20)

Application of skills (7.63)

Governed by laws of nature (7.75)

Shaped by design of engineering (8.00)

Batch size vs efficiency (customized mass production) (3.31)

Creative (9.63)

Expert systems (4.40)

State of the art (5.60)

Information content (6.75)

Technology management (7.56)

Artifical intelligence (6.00)

Functionality (6.72)

A product of scientific research (6.20)

Frequently generates hidden consequences and side effects (8.25)

Gives people new powers and responsibilities (8.08)

Safety(5.81)

Used to solve problems or create opportunities (8.67)

Little understood by most users (5.25)

Impacts on economic, social, and political dynamics (8.83)

Central to the advance of Western Civilization (8.00)

Materials and objects as physical forms that "do" something (5.80)

Manifest and latent functions (7.00)

Evolution (6.88)

A study (5.88)

Ideas about objects (6.25)

Manufacture (6.44)

Human-machine relations (8.00)

Support systems (5.67)

Gadgetry (3.60)

Processes (8.72)

Skills and techniques (8.38)

Instruments (5.15)

Devices (5.67)

Products and services (6.43)

Knowledge based (6.75)

High (modern) vs Low (pre-modern or Third World) technologies (4.75)

Works with materials (6.20)

Applied through tools and machines (7.80)

A school subject (5.78)

Purposeful, human manipulation of the material world (9.63)

Using power (6.63)

Employing techniques (6.75)

Applied science (6.42)

Technological literacy (7.75)

Maximizes benefits of technology to people (6.38)

Invention (9.25)

Use of artifacts (6.25)

Maximizes human potential (7.13)

Uncovering science (4.28)

Innovation (9.80)

Advancing civilization (6.38)

Developing the human-made world (7.92)

Extension of human potential (8.88)

Operates in natural and "built" environments (7.33)

Realizing the potential of the universe (5.67)

Adaptive systems (7.63)

"Know-how" (8.92)

Goal driven (7.80)

Applied knowledge (8.60)

Problem solving (9.13)

Technology-society relations (8.00)

Decision making (8.60)

Knowledge of application (7.63)

Human purpose (7.38)

Human capabilities (6.14)

A class of materials (4.58)

Historical (5.88)

Basic principles (6.14)

Body of knowledge (8.75)

Design is the basic approach (6.75)

Theoretical aspects (5.92)

Waste disposal (3.67)

Concerns the practical world (7.00)

Purposeful activity (7.48)

Method (7.63)

Physical technology (5.71)

Biological technology (6.38)

Impacts (6.00)

Social invention (6.67)

Social technology (5.63)

Institutional technology (5.00)

Designed operation (7.20)

Software (5.86)

System of knowledge of use and transformation of environmental resources (8.75)

Varies across cultures (7.75)

Is a function of cultural values (8.13)

Hardware (6.00)

Changes through time (8.25)

Is interposed between humans and use of the environments (7.63)

Is a function of environmental knowledge (6.19)

A study of exploitation of the physical environment (5.75)

A system of tools, knowledge, and behaviors associated with the exploitation of environments (8.63)

The system that determines population size and density (4.33)

Closely linked to science but not simply applied science (9.14)

A strategy for extracting energy from physical environments (6.00)

A variable to explain cross-cultural differences in social organization, beliefs, and culture (6.33)

An area of human activity (7.88)

Similarly, related to, but not equivalent to engineering (6.67)

An inherently value latent social process (7.80)

Cuts across time periods (6.19)

Changes in form and/or matter, energy, and information (6.92)

Mutual influence between technology and society (8.33)

Has social, economic, political, and environmental impacts (8.40)

Focused on the control or manipulation of nature (7.80)

Skills: designing, making things, using technological products (7.63)

May be material (physical device or product) or social (method of doing or making) (8.86)

Key to human evolution in the future (7.63)

Extends human capabilities (physical, social, and intellectual) (9.40)

Diffusion or adoption often involves modification (7.14)

Converges social structures (5.88)

Played an important role in the emergence of *Homo sapiens* (8.80)

A core component to all indigenous cultural systems (7.67)

Technological innovation (the appearance and uptake of new technologies) is a "stage-process" phenomenom, including invention, developmnet, deployment, and implementation (8.60)

Linked to industrial productivity and economic growth (8.20)

A process (change, individual, corporate, design, creative, and systematic) (8.81)

Resources (materials, energy, concept, physical, personal, and intellectual) (8.25)

Achievements (6.11) A purpose (social, personal and economic values, context, and assessments) (8.13)

Constraints (economic and material) (6.00)

Product (thing, system, organization) (6.38)

Curricular Organizers for the Study of Technology

The process of technology (9.33)

The engineering disciplines (mechanical, electrical, civil, etc.) (7.75)

Elements of technology (appropriateness, levels - high, intermediate, low, transfer, assessment, impacts, time line - past, present, future, tools, materials, processes, information, human, etc.) (9.13)

Standards/measurements (6.07)

The systems of technology (input, process, output), construction, production, transportation, communication, exploration, development, controlling, etc. (8.25)

The fields of endeavor (communication, manufacturing, construction, transportation, medicine, agriculture, etc.) (7.88)

Types of technology (physical, biological, information) (7.33)

Technology and work and profession (7.94)

Technology and leisure time (6.81)

Technology and environment (9.13)

Cultural organizers (communication, production, transportation) (8.00)

Product organizers (materials, processes, products, tools) (7.88)

Technology and living environment (in and around the home) (8.38)

Cognitive organizers (aeronautical, biological, chemical, electrical, information, management, mechanical, nautical) (8.00)

Process organizers (creativity, enterprise, systems, inventions, problem solving) (10.20)

Science (7.20)

Media technology (6.80)

Construction (7.80)

Communication (9.00)

Organization structures (7.63)

Agricultural (7.08)

Manufacturing (7.80)

Social factors (7.75)

Constitutencies for and against (6.25)

Physical technologies (civil, mechanical, electrical, chemical, aerospace, biomedical, forest and forest products, etc.) (8.38)

Instrumentation (7.60)

Theory of technology (9.33)

Transportation (8.71)

Service technologies (automated systems. etc.) (7.88)

Appropriate technology (8.13)

Information processing (8.60)

Energy (9.65)

Physical sciences (7.38)

Social sciences (6.80)

Food and water (8.69)

Shelter (6.88)

Biological technology (6.60)

History of technology (8.13)

Weapons and defense (7.40)

Space (7.20)

Design and innovation (9.60)

Applied physics (7.60)

Computers (8.25)

Telecommunications (8.00)

Applied chemistry (7.14)

Mechanics (6.75)

Telematics (7.00)

Geology (5.88)

Applied biology (7.13)

Ceramic (6.31)

Materials (8.25)

Automation (8.41)

Agronomy (6.31)

Pharacology (5.92)

Electronic/Electro-optical (8.08)

Micro technology (7.60)

Environmental (7.42)

Funding (6.13)

Archeology (5.67)

Economics (7.00)

Resources (Knowledge - generalized concepts and operational techniques, skills - intellectual, physical, personal, personal qualities - motivation, resoursefulness) (8.25)

Ethical implications of technology (8.92)

Cultural anthropology (6.00)

Demography (5.75)

Sociology (5.75)

Humanities (6.67)

Social studies of technology (8.67)

Public policy of technology (8.55)

Psychology (5.33)

Philosophy of technology (9.08)

Technology assessment (9.11)

Technology literacy elements (7.75)

Industry (7.60)

Technique (6.25)

Anthropological technology (5.40)

Limits of technology (9.13)

Power (7.80)

Research and development (9.42)

Values in technology (9.80)

Technology and Organizational Change (8.00)

Musical technology (6.38)

Problem solving (10.08)

Art technology (5.33)

Awareness of implications and potential of technology (health, food, communication, production, control) (9.00)

Definition of technology (6.29)

Technology transfer (8.42)

Capability (investigating, inventing, implementing, evaluating) (9.25)

Progression (6.00)

Approximately one week ago, you were mailed a questionnaire asking you to respond to two research questions relative to what will be the key descriptors of a definition of technology and what will be the appropriate curriculum organizers for the study of technology.

This is just a reminder asking you to complete and return the questionnaire as soon as possible. If you have already done this, please disregard this notice. Thank you for your cooperation.

Sincerely,

James L. Barnes
College of Education
144 Smyth Hall
Virginia Tech
Blacksburg, VA 24061

William E. Dugger, Jr.
College of Education
144 Smyth Hall
Virginia Tech
Blacksburg, VA 24061

APPENDIX E

Delphi I

Key Descriptors of a Definition for Technology

- Technology Educators

Human activity

Changes in form and/or place of matter, energy and information

Relation to sciences

Skills: designing, making things, using technological products

Mutual influence between technology and society

Creative

Adaptive system

Extension of the human potential

"Know-how"

A study *and* a process

Tools, techniques, resources, and systems

Operates in natural and "built" environment

Goal driven

Is moving from less "trial & error" to more "science" based

Knowledge: applied

Knowledge of application

Problem solving

Impacts (consequences)

Human purpose

Human capabilities

Decision making

Application of knowledge

Uncovering science

Application of science

Invention

Innovation

Engineering

Advancing civilization

Developing the human-made world

Realizing the potential of the universe

Linked to industrial productivity and economic growth

A process (change, individual, corporate, design, creative, and systematic)

A purpose (social, personal, and economic values, context, and assessments)

Resources (materials, energy, concept, physical, personal, and intellectual)

Constraints (economic, material)

Achievements

Product (thing, system, organization)

Delphi I

Curricular Organizers for the Study of Technology

- Technology Educators

Technology and work and profession

Technology and leisure time

Technology and living environment (in and around the home)

Technology and environment

The process of technology

The systems of technology (input-process-output)

The engineering disciplines
-mechanical
-electrical
-civil
-etc.

The fields of endeavor
-communication
-manufacturing
-construction
-transportation
-medicine
-agriculture
-etc.

Elements of technology
-appropriateness
-level (high - intermediate - low)
-transfer
-assessment
-impacts
-time line (past - present - future)
-etc.

Types of technology
-physical
-biological
-informational

Standards/measurement

Elements of technology
-tools (including machines)
-materials

-processes
-energy
-information
-humans

Systems for
-construction
-production
-transportation
-communication
-exploration
-development
-controlling

Change
-evolution (includes history)
-revolution

Impacts
-consequences
-futures
-decisions

Interfacing
-science (includes math)
-arts
-humanities (includes society)

Technology related to
-invention
-entrepreneurship (enterprise)
-economics
-creativity
-design

Cognitive organizers
-aeronautical
-biological
-chemical
-electrical
-information
-management
-mechanical
-nautical

Cultural organizers
-communication
-production
-transportation

Process organizers
-creativity
-enterprise
-systems
-invention
-problem solving

Product organizers
-materials
-processes
-products
-tools

Problem solving

Progression

Resources
-knowledge
-generalized concepts
-skills
-intellectual skill
-personal skill
-personal qualities
-motivation
-resourcefulness

Awareness of implications and potential of technology
-health
-food
-communication
-production
-control

Capability
-investigating
-inventing
-implementing
-evaluating

Delphi I

Key Descriptors of a Definition for Technology

- Philosophers of Education

Applications

Applied

Relates general principles to practical problems/concerns

Techniques

Procedures

Skills/How to do it

Psychoergonomics

Problem solving

Creative

Application of knowledge

Knowledge based

A purposeful process

Impacts on social, economic, and environmental structure

Delphi I

Curricular Organizers for the Study of Technology

- Philosophers of Education

Science

Engineering

Agriculture

Construction

Manufacturing

Communication

Process of technology

Problem solving

Innovation

Applied science

Values

Elements of technology

Delphi I

Key Descriptors of a Definition for Technology

- Philosophers of Technology

An activity or artifact

Purposive activity

Device

Apparatus

Means

Instrument

Techne

Designed operation or activity

Adjunct to science

Human-machine relations

Instruments

Tools

Use of artifacts

Technology-society relations

Instruments

Gadgetry

Devices

Processes

Products and services

Skills and techniques

Knowledge bases

Management or mismanagement

Consumption

Assessment

Regulation

Rational approaches

Technical interest groups

Techno-political-economic groups and attitudes

Technical ideologies

High (modern) vs. low (pre-modern or Third-World) technologies

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Delphi I

Curricular Organizers for the Study of Technology

- Philosophers of Technology

Social impact of technology

Values in technology

Development of technology

Technological interests

Technology and capital

Technology and labour

Appropriate technology

Measurement of technological impacts

Philosophy of technology

Social studies of technology

Technology and war

Technology and hunger

Limits of technology

Reproductive technology

Media technology (the politics of technology)

Economics and technology

Technology and agriculture

Who benefits from what technology

Technology in socialist countries

Technology and socialism

Philosophy of technology

Literature and technology

Ethics and technology

Musical technologies

Art technologies

Social factors (in technology)

Organization structures

Constituencies for and against

Primarily physical technologyies
-various examples from civil, mechanical, electrical, chemical, aerospace, and biomedical engineering

Processes

Service technologies
-examples such as automated systems

Instrumentation

Handcraft techniques:
-examples from premodern times and non-industrialized cultures (preferably contrasted with "high" technologies for comparable tasks)

Delphi I

Key Descriptors of a Definition for Technology

- Historians of Technology

A study of man-made artifacts

Analysis of the interaction of systems and society

Incorporates social, economic, and political factors/influences

Interdependence of machines, "software," and people using them in specific contexts

A field of study

An area of human activity

Closely linked to science but *not* simply applied science

Similarly, related to, but *not* equivalent to engineering

An inherently value laden social process

Has societal, economic, political and environmental impacts

Cuts across cultures, but can be very culture specific

Cuts across time periods

A practical activity

Focused on the control or manipulation of nature

Using scientific or other forms of knowledge or skills

Influenced by social and economic conditions

Purposeful, human manipulation of the material world

Works with materials

Using power

Applied through tools or machines

Employing techniques

Delphi I

Curricular Organizers for the Study of Technology

- Historians of Technology

History

Engineering

Economics

Politics

Sociology

Social studies of technology

History of technology

Philosophy of technology

Public policy of technology

Risk/cost-benefit analysis

Technology assessment

Reflected in fine arts and literature

Technology "literacy" elements

Mechanical technology

Civil engineering technology

Electrical technology

Chemical technology

Mineral technology

Forest and forest products technology

Manufacturing technology

Electronics technology

History of technology

Technology policy

Social impact of technology

Technology and industrial organizations (technology management)

Technology and values/ethics

Technology and the environment

Philosophy of technology

Technology literacy

Engineering

Industry

Science

Arts

Craft

Research and development

Materials

Power

Tools or machines

Technique

Delphi I

Key Descriptors of a Definition for Technology

- Anthropologists of Technology

May be material (physical device or product) or social (methods of doing or making)

Played an important role in the emergence of *Homo sapiens*

An integral part of human biological evolution in the past

Key to human evolution in the future

Extends human capabilities (physical, social and intellectual)

A core component of all indigenous cultural systems

Specific technologies (types or lines of technology) are "appropriate," or their effectiveness is relative to, specific cultural contexts

Evolves or changes over time, and change is linked to the development of cultural systems

Diffuses, or is transferred, across cultural boundaries; diffusion involves law-like processes

Diffusion of adoption often involves modification

Change in technology has primary, secondary and tertiary effects in social and economics systems

Specific technologies have life cycles, including birth, growth, maturity and decline (obsolescence)

Technological innovation (the appearance and uptake of new technologies) is a "stage-process" phenomenon, including invention, development, deployment and implementation

Innovation occurs in material and social technologies

The development of science has increased the rate of technological innovation

The rate of technological innovation is linked to industrial productivity and economic growth

A global convergence in technology is driving a partial convergence in social structures

Technology is an important variable shaping the structure and behavior of formal work organizations in the United States and other nations

System of knowledge of use and transformation of environmental resources

Changes through time

Varies across cultures

Is interposed between humans and use of the environment

Is a function of cultural values

Is a function of environmental/resource knowledge

A study of human exploitation of the physical environment

A strategy for extracting energy from physical environments

A system of tools, knowledge, and behaviors associated with the exploitation of environments

A variable to explain cross-cultural differences in social organization, beliefs, and values

A functional system which determines expressive elements of culture

The system which determines population size and density

A study

Materials and objects as physical forms that "do" something

Ideas about objects

Manifest and latent functions

Manufacture

Evolution

History

Support system

Delphi I

Curricular Organizers for the Study of Technology

- Anthropologists of Technology

Definition of technology

Technology and human evolution

Technology and culture

Technology and economic growth

Technological innovation/change

Appropriate technology

Technology transfer

Ethical issues in technological change

Technology and organization theory

Archeology

Cultural anthropology

Engineering disciplines

"Hard" sciences

History

Anthropology

Economics

Ecology

Demography

Engineering

Sociology

Environmental studies

Engineering

Computer programming

Business management

Physics and chemistry

Psychology

Social sciences (e.g., anthropology, geography, history, sociology)

Humanities (e.g., anthropology, history)

Delphi I

Key Descriptors of a Definition for Technology

- Futurists

Body of knowledge

Concerns the practical world

Includes products, devices, and systems

Broader than engineering

Design is the basic approach

Applied science

Technique

Method

Invention

Social invention

Physical technology

Social technology

Biological technology

Institutional technology

Engineering

Social engineering

Innovation

Basic

Applied

Hardware

Software

Process

"Know-how"

Theory

State of the art

Batch size vs efficiency (customized mass-production)

Information content

Creative

Technology management

Expert systems

Artificial intelligence

Functionality

Safety

A product of scientific research

Used to solve problems or create opportunities

Frequently generates hidden consequences and side effects

Little understood by most users

Gives people new powers and responsibilities

Impacts on economic, social, political dynamics

Central to advance of Western civilization

Delphi I

Curricular Organizers for the Study of Technology

- Futurists

Energy

Food and water

Weapons and defense

Manufacturing

Information and computing

Shelter

Transport and communications

Space

Health, medicine and drugs

Design and innovation

Engineering science

Applied chemistry

Pharmacology

Engineering
-civil
-mechanical
-etc.

Applied physics

Mechanics

Computers

Information technology

Telematics

Telecommunications

Geogology

Biology (applied)

Agronomy

Ceramics

Automotives

Medicine, clinical

Materials

Energy

Electronic - electro-optical

Biological

Systems/models

Macro environmental

Materials

Information especially automated programming and pattern recognition (electro-optical)

Automation

Biological/genetic

Medical

Communication

Environmental

Biological

Chemical

Physical

Information

History of

Ethical implications of

Assessment

Forecasting

Engineering

Space

Funding

Delphi I

Key Descriptors of a Definition for Technology

- Industrialists/Business Leaders

A study

A school subject

Applied science

Technological literacy

Maximizes human potential

Maximizes benefits of technology to people

A class of materials

Historical

Theoretical aspects

Basic principles

Techniques for fabrication

Applications

Waste disposal

A process

Often known by its embodiments (products)

Workings, (works) of humans

Application of knowledge

Application of tools

Application of skills

Servant to society

Governed by laws of nature

Shaped by designs of engineering

Applied science

Quality of life

Encyclopedia

Systematic treatment of an art

Pansophic

Pantologic

Know-how

Practice of manual arts and skills

The entire body of methods and materials used to achieve specific objectives

Delphi I

Curricular Organizers for the Study of Technology

- Industrialists/Business Leaders

Theory of technology

Communications

Information processing

Manufacturing

Transportation

Energy

Construction

Lecture courses

Laboratory experiences

Research

Library

Independent study

Physical sciences (total coverage)

Biological sciences (total coverage)

Social sciences (total coverage)

Industrial arts (partial coverage)

Technology education (partial coverage)

History (partial coverage)

Linguistics (partial coverage) (Information tech.)

Manufacturing technology

Transportation technology

Construction technology

Space technology

Biomedical technology

Socio-technical technology

Management technology

Communications technology

Information systems technology

Artifical intelligence technology

Vision systems technology

Commerce technology

Financial technology

Integrated systems technology

Distribution systems technology

Materials technology

Education technology

Nuclear technology

Agriculture technology

Agriculture technology

Genetic technology

Environmental technology

Simulation technology

Energy technology

Industrial technology

Services technology

Political technology

Packaging technology

Photographic technology

APPENDIX F

DELPHI PANELS

Technology Education Professionals

1. Tom Hughes, Associate Director
   Technology Education Service
   Virginia Department of Education

2. Ron Todd, Professor
   Department of Technology
   New York University - Washington Square

3. Geoffrey B. Harrison
   National Centre for School Technology
   Trent Polytechnic
   United Kingdom

4. Dr. Jan H. Raat
   Eindhoven University of Technology
   The Netherlands

5. Dr. M. James Bensen, Dean
   School of Industry and Technology
   University of Wisconsin-Stout

Philosophers of Education

1. Dr. Jack Frymier, Senior Fellow
   Phi Delta Kappa - International Headquarters

2. Dr. Harold Shane, Professor
   School of Education
   Indiana University

Philosophers of Technology

1. Alex Michalos, Professor
   University of Guelph
   Nova Scotia

2. Paul T. Durbin
   Department of Philosophy
   University of Delaware

Anthropologists of Technology

1. Willis Sibley, Professor
   Department of Anthropology
   Cleveland State University

2. Marietta Babo, Professor
   Department of Anthropology
   Wayne State University

3. Edward Knipe, Professor
Department of Sociology & Anthropology
Virginia Commonwealth University

4. Wendall Oswalt
Department of Anthropology
University of California - Los Angeles

Historians of Technology

1. Terry S. Reynolds, Director
Program in Science, Technology & Society
Michigan Technical University

2. Jeff Sturchio, Acting Director
Center for History of Chemistry
University of Pennsylvania

3. Stephen Cutcliffe
STS Program
Lehigh University

4. Alex Roland
Department of History
Duke University

Futurists

1. Joseph Coates
JF Coates, Inc.
Washington, D.C.

2. Chris Dede, Associate Professor
College of Education
University of Houston at Clear Lake

3. Selwyn Enzer, Associate Director
Center for Futures Research
University of Southern California

4. Dr. Robin Roy, Lecturer
Faculty of Technology
The Open University
United Kingdom

Industrialists/Business Leaders

1. Dr. W. Lincoln Hawkins, Consultant
Materials Engineering
Montclair, NJ

2. Forrest D. Brummett, Chief Engineer
Allison Division of General Motors
Martinsville, IN

3. Dr. James R. Johnson
River Falls, WI

4. George L. Fricke
Director of Training
New Jersey Bell
South Plainfield, NJ

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VITA

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