TECHNOLOGICAL LITERACY: THE ESSENTIAL CRITERIA FOR A DEFINITION

By

DENNIS R. BAKER

Bachelor of Science in Education
Emporia State University
Emporia, Kansas
1965

Master of Science in Education
Pittsburg State University
Pittsburg, Kansas
1966

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF EDUCATION
July, 1988

TECHNOLOGICAL LITERACY: THE ESSENTIAL

CRITERIA FOR A DEFINITION

Thesis Approved:

Thesis Adviser

Dean of the Graduate College

ACKNOWLEDGMENTS

Sincere appreciation is expressed to Dr. Garry Bice, the researcher's major advisor, for his understanding and guidance and the opportunity to work and learn from his leadership throughout the study. Appreciation is extended to the committee members: Dr. Cecil W. Dugger, Dr. James Key, and Dr. Robert Wicklein for their assistance with the study.

Special thanks is given to the secretaries of the School of Occupational and Adult Education, Kay Porter, Marie Roe, and Wilda Reedy for all of their help.

To the participants who were so faithful with their responses, a note of gratitude is extended for their cooperation and support.

I wish to give a final word of thanks to my family. First, and foremost, I wish to thank my wife Kathy for her love, assistance, and encouragement. A special thank-you must go to Don and DeAnne for their sacrifices and understanding while Dad was in school. It is to my family and parents that this study is dedicated.

TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

The quality of our education system has been challenged from our kindergartens through our universities. The first paragraphs of the Report of the National Commission on Excellence in Education, A Nation at Risk: Imperatives for Education Reform (1983), were a call to arms to improve education in order to restore our, ". . . once unchallenged preeminance in commerce, industry, science, and technological innovations . . ." (p. 5). Pervasive throughout this and other reform movements has been the importance of the study of technology as an essential element for a technologically literate citizenery.

Some responses to the situation have been that a number of state departments of education have revised and/or modified traditional Industrial Arts programs to focus on technology and technological literacy (e.g. Oklahoma, New York, Indiana). At the same time, many of the goals and objectives of those programs are being developed to focus on the development of technological literacy among students.

The scientific method of development has been one of the reasons for the rapid advancement in technology. One of the key steps or processes in the scientific method is to "clearly define" the problem or situation. The artist, social scientist, business person, technologist, and physical scientist all have different points of view as to just what technological literacy is (Ley, 1987). Each of these individuals has a vested interest in being technologically literate. At the Technology Education Symposium IX, in Dallas, Texas, October 10, 1987, Foy stated, "The literature of the early to mid-eighties spoke of scientific literacy and technological literacy without clearly defining what each meant" (p. 35). At the same symposium, DeVore (1987) stated: "There are many inconsistencies and confusions on the use of the term technological literacy" (p. 34).

Dyrenfurth (1987), international authority on the subject of technological literacy, addressed the many misconceptions that have been associated with technological literacy, "We are shocked at the misinterpretations, although well-intentioned, that are driving many of the feeble steps that we are seeing in program changes in America's schools" (p. 1).

Statement of the Problem

The problem, then, is that although the term technological literacy is in common use, and many programs are being revised to reflect that emphasis, there is no generally accepted definition of technological literacy among those responsible for providing leadership and direction. The efforts to correct the inadequacies that the _A Nation at Risk Report_ (1983) addressed concerning technological innovations will not be successful until some generally acceptable definition of technological literacy is developed, and the essential criteria are identified to verify this definition. The problem of this study stemmed from the general misunderstanding and the multiple interpretations of the term technological literacy.

Need for the Study

All areas of education have become concerned with the need for a technologically literate citizenery. The report, Educating Americans for the 21st Century (National Science Board, 1983) stated, "Technology topics need to be integrated into the present curriculum. This includes science and mathematics classes, industrial arts, social studies and language arts, and art and music" (p. 75). "Furthermore, technological literacy is considered to be an essential characteristic of those with a quality general education" (Dyrenfurth, 1987, p. 3).

Boyer (1983), former president of the Carnegie Foundation, cited the need for a technologically literate citizenry in his book titled High School: A Report on Secondary Education in America (1983):

> 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).

Copa (1981) encouraged vocational education researchers to move into the realm of posing research questions that examine meanings and ends. Ley (1987) stated, "There is a myriad of examples of definitions of technology, and defining technological literacy is no less difficult. In fact, it is a question of meaning worthy of investigation by researchers" (p. 2).

La Porte (1986) identified six challenges that education must meet. One of the most important was, "A clear definition of technological literacy and technology education must be communicated to the various constituencies which are to be served" (p. 71).

According to Smalley (1987), the development of a satisfactory definition of technological literacy has proven difficult for several reasons: There is little agreement about the criteria that should be used to identify a technologically literate individual; very few measuring instruments exist and those that do are not as precise as they should be; and the needs of the different professional groups concerned vary widely. Each professional group considers the need to be technologically literate from a different perspective, and the groups work from a different training philosophy and goals. For the educator, a useful definition of technological literacy should offer clear criteria that can be used to teach all individuals toward becoming technologically literate.

DeVore (1987) noted there is mass confusion not only within the fields commonly identified as science and technology, but also in the minds of academicians, and other people responsible for a wide range of affairs concerning science and technology.

> Because there is so much confusion about the use and meaning of the terms, and their meanings are central to issues of public policy ranging from establishing programs to enhance the technological literacy of the general citizenry, to determining the expenditure of research funds, the first task is to concentrate on describing the nature of the problem - identifying what constitutes technological literacy (p. 2).

Smalley (1987) recommended further research to verify and validate the criteria identified by Smalley and Brady (1984). "Before a test for technological literacy can be developed, the criteria for a definition must be identified, and furthermore, technological literacy should be clearly defined."

Purpose

The purpose of this research was to identify the essential criteria that characterize a technologically literate person using a Delphi process involving recognized leaders in the areas of education, business and industry, and vocational administration. A definition of technological literacy was then postulated from the criteria identified.

Research Questions

Specifically, the following research questions were posed to guide the study:

1. What are the criteria that characterize a technologically literate person?

2. What is the relative importance of each of the technological literacy criterion.

3. Do business and industry representatives, professional educators, and vocational administrators rank the technological literacy criteria differently?

4. What is a definition of technological literacy based upon the criteria established?

Assumptions of the Study

The following assumptions are pertinent to the conduct of this study:

1. The responses to the questions are conscientious expressions of attitudes, opinions, and beliefs of the experts.

2. The instruments used in this study were adequate for allowing

the experts to report their opinions and beliefs.

3. The process of nomination was unbiased and yielded nominations of individual representatives of experts in the field.

Scope and Limitations of the Study

1. The results and conclusions were based upon the opinions and judgements of the experts identified for this study and may not be representative of all in the nation.

2. The study was limited to defining one area only - technological literacy.

Definition of Terms

The following terms were used in this study:

Business and Industry Representatives-Those who are familiar with the materials, processes, and organization of business and industry through their involvement and experience.

Consensus-An opinion held by all or most; General agreement (Webster, 1984).

Criteria-A standard, rule, or test by which something can be judged (Webster, 1984). Standards or parameters for decision making.

Define-To determine the limits or nature of; To state the meaning of (Webster, 1984).

Experiential-Pertaining to or deriving from experience. The process of learning by doing.

Industrial Education-This is a generic term used in referring to vocational education, industrial arts, technology education, apprenticeship, and the offerings of private trade schools.

Postulate-To assume to be true; to propose as a basis for argument (Webster, 1984).

Probe-Round-Refers to the surveys in a Delphi study used to gather information.

Professional Educators-Those who are involved in teacher education at the college and university levels and are known for their research and publications.

Vocational Administrators-Those who have the responsibility of providing leadership to vocational programs at the state and national levels.

Vocational Education-A generic term that embraces all the experiences an individual needs to prepare for some useful occupation.

CHAPTER II

REVIEW OF LITERATURE

Introduction

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 has echoed the report, A Nation at Risk, (1983) to overhaul their education system. At no time in recent history has so much attention been focused upon American education and the need to improve the content, delivery and evaluation of programs.

Following the report, A Nation at Risk (1983) more than 30 reports issued by task forces, commissions, and individuals urged that immediate attention be given to our schools. Balistreri (1988) found that 16 such reports had specifically addressed the topic of technology or technological literacy. The total educational system was encouraged to include the study of technology for all students. "All students should study technology: the history of man's use of tools, how science and technology have joined, and the ethical and social issues technology has raised" (Boyer, 1983, p. 304). The report, Educating Americans for the 21st Century by the National Science Board Commission (1983) made a number of references to technology emphasizing the importance of its relationship to all subjects in the curriculum:

> The study of technological systems should be used as a basis for providing integrated and holistic learning. This is our reason for suggesting that all academic departments be involved. We cannot afford to repeat the mistakes of the past (p. 84).

In addition, the report was careful to point out that the study of technology provides a motivation for students to apply the concepts of math and science. "When technology is used to introduce scientific thinking, it will appeal to the student as more interesting and relevant, and hence be a motivator" (p. 73). Hurd (1968) conducted a national survey of student achievement and concluded that we are raising a new generation of Americans that is scientifically and technologically illiterate. In a similar vein, Slaugher (n.d.), former Director of the National Science Foundation, warned of a "growing chasm between a small scientific and technological elite and a citizenery ill-informed on issues with a science component" (cited in A Nation at Risk, 1983, p. 10). Because of these and other such bold statements, our education system was forced to make changes in all areas of instruction including science, math, English and language, as well as the understanding of technology and its application to the academic areas. With this new emphasis on technology came many misinterpretations of its meaning and purpose.

Throughout the literature on educational reform, conflicting uses of the various terms can be found. "One serious misconception is the mistaking of computer literacy for technological literacy" (Dyrenfurth, 1987, p. 1). There is a strong inclination to equate technology with computers. It is obvious that the computer is important in today's society and has great value as a learning tool, but as Dyrenfurth (1987) pointed out, computers are but one part of the technological "species." Boyer (1983) recognized that the great urgency is not computer literacy, but technology literacy - the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history. Boyer expressed his disappointment in his study of technology in the schools: "More disturbing still is the inclination to equate technology with computers" (p. 111).

Another area of concern is the confusion of science with technology. Dyrenfurth (1987) states emphatically, "Technology is not Science!" (p. 1). Kranzberg (1983), one of America's leading scholars of technology, stated at the Chicago Museum of Science and Industry's 50th anniversary: "For much of history, science and technology were two separate activities carried out by different communities who rarely came in contact with one another; They used different methods and sought different goals" (p. 8). If one looks carefully, one can discern that even the scientists recognize that science is not the same as technology. In addition, Andrews (cited in Dyrenfurth, 1987) referred to numerous authorities who repeatedly use phrases such as the interaction of science, technology and society; or a society, its technology, its science.

DeVore (1987) noted many inconsistencies and confusions on the use of the terms "science" and "technology". He stated, "Time and time again research reveals reports using the terms 'science' and 'technology' which report on science and do not mention anything about technology" (p. 23). He concluded that technology is a definite part of science and the two must work together even though the terms do not mean the same.

Technology

The broad term of technology has been used to explain the history of man's superior being by his invention to use tools, fire, and produce food. All through history the human race has advanced above all other forms of life in the development of ways to satisfy life's basic needs of food, shelter, and clothing (Washburn, 1962). The term technology has been used frequently to describe this progress. However, during the 18th Century many new innovations began to emerge at a rapid pace over much of the world with the Industrial Revolution. This pace has accelerated to the point where the term technology has over 50 definitions and the word is being used by everyone to fit their own specific need (Balistreri, 1988). According to Maley (n.d.), technology hinges on its heritage and involves all areas of concern:

> The heritage of technology is its dominance in the history of human existence down the long road of time. It has taken the human from a position of complete dependency on the environment to the present where mankind has demonstrated a capability for transforming the environment to meet his needs. Technology has been the instrument of change and progress as well as disruption and destruction. Created out of the genius of humankind, the evolving technology has become a dominant factor in practically all areas of man's existence. The arts of music, medicine, cummunication, construction, production, distribution, transportation, and commerce are tangible evidence or expressions of the human's ability to devise, produce and use technology (p. 1).

Washburn (1962) noted, ". . . it was the success of the simplest tools that started the whole trend of human evolution and led to the civilizations of today" (p. 13).

The National Reports on educational reform have frequently addressed technology and its applications in America's schools. Most of the reports agree that people must know about technology in order to improve the quality of many personal and professional technology-based decisions. The report, Educating Americans for the 21st Century (1983) suggested that people must understand the limitations as well as the capabilities of emerging technologies and have a sense of what technology can do. Special emphasis was placed on the need to tie science and mathematics to the experiential style of learning to discover the applications within technology related fields. However, the real meaning of technology was never explained.

The Nation at Risk Report (1983) similarly addressed the topic of computers, lasers, robotics and occupations in regard to technology. "Knowledge of the humanities must be harnessed to science and technology if the latter are to remain creative and humane, just as the humanities need to be informed by science and technology if they are to remain relevant in human condition . . ." (p. 10). The report used the term "excellence" to emphasize several related topics, one of which is technology, "Excellence characterizes a society that has adopted the new technological policies, for it will then be prepared through the education and skill of its people to respond to the challenges of a rapidly changing world" (p. 12). Again, technology was left without a clear definition of its purpose and meaning.

The Task Force on Education for Economic Growth (1983) voiced concern over technological change in America, "To many Americans, technological change today seems a dark and threatening force, rather than a bright confirmation of our national genius" (p. 13). The conditions that concern us today - swiftly advancing technology; economic competion world-wide; the sudden obsolescence of skills - will be even more intense tomorrow and a clear understanding of technology and its principles must be clearly understood.

Boyer (1983) offered a clarification of technology in his recommendation that all students study technology:

> 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. During this proposed one-semester course, a student might well look at one technological advance - the telephone, the automobile, television, or the minicomputer, for example - trace its development, and examine the positive and negative impact it has on our lives today. . . (p. 110).

With the emphasis placed upon the need for the study of technology by the various reports dealing with educational reform, a number of studies have been conducted by educators in an attempt to clarify the vague meaning of technology found in the reports. Dyrenfurth (1984) noted two of the many ways that the concept of technology is frequently used:

> 1. As a discipline, the term technology denotes a field of study in the same way that geology, biology or anthropology are used.
>
> 2. As a system, technology refers to a purposefully organized collection of hardware and software used to achieve a desired end (p. 7).

In addition to the two concepts of technology Dyrenfurth (1987) cited five interpretations of technology:

> *Technology practices in order to test or refine theories of efficient action which can only be derived from practice. Knowledge (ology) of practice (techn) is technology [Lux 1983, p. 1]. It is praxiological knowledge -- the knowledge of practice!
>
> *Technology [is] . . . knowing how to do something from the rules, sometimes from scientific theories, sometimes from pragmatic experience (technic) [Smalley n.d., p. 20].
>
> *Technology is a social process in which abstract economic, cultural, and social values, shape, develop and implement specific artifacts and techniques that emerge from the

distinct technical problem-solving activity called engineering which is embedded in that process [Cutcliffe 1981, p. 36]

*Technology is made up of physical elements invented or created by human beings [DeVore 1980, p. 3].

*Technology is the creation and utilization of adaptive systems including tools, machines, materials, techniques and technical means, and the relation of the behavior of these elements and systems to human beings, society, and the civilization process (Dyrenfurth, 1987, p. 7).

Barnes (1987) identified 14 items relative to the key descriptors of a definition of technology. From data obtained he found that the definition was best described in terms of statements that emphasize concepts and processes. The data also appeared to indicate a strong emphasis on the technological relationships 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 Barnes:

> The data show a strong emphasis for describing the definition of technology in holistic terms, rather than focused to a specific type of technology. Likewise, the data place 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 and problem solving through a systems approach (p. 134).

In a similar study to identify organizers for curriculum design, Balistreri (1988) found the term technology being used not only by educators, but also by the publics of industry, current best sellers, and current magazines and journals. Balistreri identified two elements that were common to all literature in relation to technology: (1) Knowledge that extends the human potential, and (2) Interfaces with the sciences and humanities. From this he concluded: "Technology is the knowledge that extends human potential which is multidisciplinary in nature" (p. 3).

Among the many examples of definitions for technology, some are derived from a mechanical perspective, relating to machines, and in many respects focus specifically on the computer as technology. At the other end of the definition scale are the definitions of technology with a much more comprehensive sense including both physical and social constructs of the phenomenon (Hughes, 1985). Ley (1987) listed four examples of definitions that might be applied to a similar scale:

> 1. Technology is tools, machines, power, instrumentation, processes, and techniques.
>
> 2. Technology is knowledge created and being created by humans.
>
> 3. Technology can be either physical or social. A new social organization is as much a technology as a new machine.
>
> 4. Technology is applied science; a technical method of achieving a practical purpose; the totality of the means employed to provide objects necessary for human sustenance and comfort (p. 5).

Each of these definitions portrayed technology in some similar and yet dissimilar modes. There are some common elements related to technology in each definition. The development of new means for accomplishing tasks or reaching goals and the process of applying knowledge appear to be generic themes.

Although agreement on the definition of technology is not apparent in the literature, there are some basic assumptions that appear as pervasive themes (Loepp, 1986). These include:

1. Technology extends the potential of human beings.
2. Technology fosters ignorant and dependent human action.
3. Technology has an impact on social institutions.
4. Technology transcends global boundaries.

Literacy

The term literacy is equally misinterpreted. In much of the literature the explanation of literacy is accompanied by the term illiterate, usually presenting facts and figures to indicate the condition of America's population in regard to education. For example, Kozal (1985) estimated that more than 25 million adults read below a fifth-grade level and another 35 million read below a ninth-grade level. But his contention that a third of American adults are functionally illiterate has come under fire recently as a gross overstatement of the literacy problem.

A literacy level depends upon the standards used to define it. Until the Civil War the simple ability to sign one's name was the literacy standard (Teske, 1987). However, the definition of literacy today includes mastery of basic competencies used in everyday life - such as reading a newspaper, interpreting road signs, bus schedules and maps. An eighth-grade reading ability, the determinant of literacy since World War II, may assess inaccurately the number of adults who have trouble understanding everyday reading and instructional tasks (Teske, 1987).

Literacy takes on meaning in relation to the historical and social setting. According to Arnove and Graff (1987), nations, where skills constitute literacy, change over time and differ by setting, causing estimates of illiteracy to vary greatly from time to time and from place to place. In general, environments that are more technologically complex are thought to require reading and writing skills that are more sophisticated. Thus, "there will be calls for renewed efforts to teach higher-order literacy skills" (p. 206).

The report, Action for Excellence: A Comprehensive Plan to Improve Our Nation's Schools (1983) gave a synopsis of the meaning of literacy:

> This kind of redefinition has happened before. Over the years, our concept of literacy, for example, has undergone considerable revision, as technology has advanced in America and as the demand for knowledge has increased in the workplace. In the nation's early days, to be literate meant simply to be able to write one's name. Later, literacy came to mean the ability to read, write and compute - at a rudimentary level, to be sure; but at a level higher than was common among unskilled workers a century ago or even fifty years ago (p. 15).

The literature strongly suggested that the term literacy is based upon its application and the setting for which it is intended must be clearly defined. Definitions of literacy were found to vary from quite simple to complex. The 1970 Harris Poll showed that literacy had come to mean "the ability to respond to practical tasks of daily life" (p. 10). Balistreri (1988) defined the term by combining information from Webster's Dictionary (1986) and Bloom's Taxonomy (1956). The resulting broad definition identified literacy as: "Possessing higher order thinking skills—analysis, synthesis, evaluation" (sic. p. 3).

The most complete definition, perhaps, was developed by Luehrman quoted by Dyrenfurth (1987):

> Literacy . . . means the ability to read and write, that is to do something with a language, not merely to recognize that language is composed of words, to identify a letter of the alphabet, or to be aware of the pervasive role of language in society (cited in Benderson, 1983, p. 5).

When the two terms technology and literacy are combined, the meaning of technological literacy becomes much more involved than merely a combination of words. Thus the meaning has become confused and often difficult to interpret.

Technological Literacy

As was true for technology and literacy, defining technological literacy is no less difficult. "To examine the concept of technological literacy, one must initially define it. As is the case with so many of our worrisome yet important concepts, there is no consensus on the meaning of such terms" (Ley, 1987, p. 2). The literature reveals diverse perceptions of what constitutes technological literacy. According to Loepp (1986), technology is best viewed as problem centered. Thus the education of a technologically literate person, if we adhere to Loepp, should take an interdisciplinary, integrated, problem-solving approach.

Ley (1987) related that mere technical competence is not sufficient in the quest for literacy. "In fact, technical competence is a very low priority for most of the citizenery" (p. 5). Only seven percent of all new jobs projected for the remainder of the century will be in high-tech areas (Dyrenfurth, 1983). For these reasons, the thrust for a definition of technological literacy should be less in the direction of technical training and more in the realm of technology awareness and sensitivity - more about what it implies than how it operates (Ley, 1987).

In the recent past, much attention has been given to the need for a return to the basics in education. On the surface, this appears to reflect a consensus. However, much disagreement exists on what constitutes these basics. This fact, coupled with the economic crisis of the late 1970's and early 1980's, probably can be credited with the renewed attention being focused upon education. Task forces, commissions, individual research commissioned by organizations, joint industry-education study groups, and foundations have recently come forward with observations and recommendations for providing educational remedies to problems. The report, Educating Americans for the 21st Century (1983) stressed the importance of technological literacy directed toward the needs of our future citizens. The Report listed the following rationale in support of technological literacy from a science and mathematics point of view:

> 1. Technological literacy needs to be a part of general literacy and "numeracy." In a sense we are speaking of "basics" in education, and we are identifying the knowledge and understanding of technology as basic. Technological literacy is quite different from scientific literacy and mathematical literacy. An understanding of scientific and mathematical concepts doesn't automatically result in a understanding of technology.
>
> 2. People must know about technology in order to improve the quality of many personal and professional technology-based decisions.
>
> 3. Technological literacy prepares individuals for intelligent participation as informed citizens in the transition from an industrialized society to a post-industrialized service and information age.
>
> 4. Technological literacy will encourage greater participation by individuals in shaping public policy, which often involves the use of sophisticated technology. It will tend to encourage civic responsibility and overcome voter torpidity, which can arise out of a lack of understanding of new technologies (p. 73).

Hersh (1983) suggested that literacy is more than the back-to-basics advocates promote - "that the competence to sort, analyze, and synthesize a virtual bombardment of information" is essential (p. 637). He stated that, "in the post-industrial age, the difference between the haves and the have-nots will be measured in terms of technological literacy" (p. 637). Hersh further described this technological literacy as extending beyond knowledge of mathematics, science, and computer technology:

> One must also know how to use this knowledge. Within this frame of reference, technological literacy means possession of the necessary abilities to engage in complex thinking, i.e., the possession of an appropriate fund of knowledge and the skills to tap a continuously changing information base.
>
> More than ever, critical thinking is necessary for effective functioning - and critical thinking does not derive solely from high-quality instruction in science and math. Deficiencies in students' performances in these areas are only symptoms of the more fundamental problem of poor school practices (p. 637).

Ley (1987) found that technological literacy suggests that persons have the knowledge that allows them to use technology to best address the particular requirements of the workplace and although people see the advantage of using technology and find convenience in the use of new technology, they do not become overly dependent on that same technology. The skills of the technologically literate worker are those transferable work skills that are essential to both employer and employee in today's and tomorrow's environment.

Based upon their analysis of occupational trends in a technological world, Levin and Rumberger (1983) contend that most future jobs will not require a high level of mathematics, science, and computer skills. They proposed three guidelines for planning future educational programs:

> First, the general educational requirements for creating good citizens and productive workers are not likely to be altered significantly by high technology. Everyone should acquire strong analytic, expressive, communicative, and computational skills as well as extensive knowledge of political, economic, social, and cultural institutions. . .
>
> Second, since we cannot predict in any precise sense which jobs will be available to particular persons, which jobs they will select from among those available, and what the characteristics of jobs will be over a forty-year working life, it is best to provide students with a strong general education and ability to adapt to a changing work environment. Such adaptation requires a sufficient store of information about

> culture, language, society and technology, as well as the ability to apply that information and acquire new stressed, as opposed to specific training, especially for young students. . .
>
> Third, if changes in work requirements arise abruptly and change occurs at a faster rate than previously, the educational system may need to respond more quickly and efficiently to training needs. It may require better ties with industry and should not exclude the possibility of more industry-based training activities (p. 12).

These views do not differ significantly from those of Jones, Lauda, and Wright (1982), who proposed to defer vocational choice until after grade 12 so that an adequate background for career decision making and vocational maturity may be accumulated.

> Considering the complexity of our technological society, we could begin to take advantage of the extended adolescent period by emphasizing more career/technology awareness at the primary and secondary level. A new structure should be developed for the technical professionals of the future by reorganizing the vocational education program and providing its services as a funded postsecondary educational opportunity (p.17).

In relation to this concept, Peters (1988) related an articulation agreement considered in the State of Oklahoma to better serve the people by allowing the Vocational-Technical system to work together with the State colleges that offer B.A. Degrees to allow college credit for courses that deal with technical education. The courses dealing with the related areas would be taught on the college campus while the technical skill development would be taught in the vocational-technical setting. This relationship between vocational education and higher education is one approach to expand technological literacy.

The emphasis of the study of technological literacy has not been without controversy. Dyrenfurth (1987) contends that the impetus for technological literacy originated among the ranks of the liberal arts:

> In America, the earliest form of collective argument for technological literacy known to me stemmed from the industrial arts profession. It began with the publishing of Warner's earlier work; A Curriculum to Reflect Technology (1965). Then the field's references to the topic increased rapidly. Most of them significantly preceded the attention of our science and liberal arts colleagues. Frankly, in our country, the bulk of scientists and their liberal arts ilk just did not deem the study of technology important until the force of public opinion resulting from the weight of several generations of neglect loomed so large that they simply could no longer ignore it (p. 34).

As a result of this and other conflicts the question before us is, "Who should deliver the programs to teach technology?"

Technology Education

Forty years ago, the technical courses taught in the public schools, as well as the state teachers colleges and teacher education institutions, centered on materials-based criteria such as woodworking, metals, drafting, and crafts. This subject matter arrangement was grouped into the course known as Industrial Arts Education. In the 1950's and 1960's changes began to emerge in higher education when many teacher colleges grew into state universities with objectives much broader than just teacher preparation. Throughout the 1970's the demand for more sophisticated technical courses to prepare industrial supervisors and industrial technologists changed the teaching role of many university faculty. The enrollments in Industrial Technology programs increased rapidly while enrollments in the Industrial Arts area declined dramatically. Without the Industrial Technology majors, many industrial arts teacher education programs would have closed due to lack of enrollment (Erekson, 1987).

To allow for this change in mission, the teacher education programs combined with other departments to administer their programs. For example, education students enrolled in design courses taught by the Engineering Department with faculty who have extensive background and experience in the technical area and little experience or interest in public school teaching.

Through this transition period a new name began to be associated with the need for technology instruction in the public schools. This technology education movement, patterned after Warner's (1965) Curriculum to Reflect Technology, caused some institutions to experiment with innovative Technology Education programs. Through a number of different curriculum projects such a IACP, SEK, CBIA, and others it was generally conceded that the general areas of Transportation, Manufacturing, Construction, and Communications be the foundation for the programs. These program approaches paralleled the experiential approaches of BSCS (Biology) and PSCS (Physics) programs and like many of the other new curriculum experiments failed due to the support of the profession. Erekson (1987) eluded to the struggle that exists within the Technology Education movement:

> It has taken decades for the profession to begin to endorse/ adopt Technology Education - and the endorsement/adoption is by no means unanimous today. Thus one might predict that it will take decades for substantive changes to reflect technology education to be adopted in teacher education (p. 37).

Even though resistance to change is present, many advancements have been made toward the study of technology. The once separate studies of math, science, physics, and writing have been identified as important components of the study of technology (Educating Americans for the 21st Century, 1983). Technology Education can deliver the actual application of these principles. Barnes (1987) identified 14 descriptors that he labeled curricular organizers for the study of technology. The most important were problem-solving, processes, values, design and innovation, and research and development, which all involve applications of mathematics and scientific principles. Wright (1984), however, contends that technology should be more than a study of science, mathematics and technology. Waetjen (1985) presented a parallel view when he wrote, "A central role of an educational institution is to offer a curriculum that gives its students a basic understanding of the society in which they live" (p. 9).

Today's technology education philosophy is, for the most part, a result of the Jackson's Mill Industrial Arts Curriculum Symposium where a group of 21 individuals met over an 18 month span in 1980 and 1981 to live the "challenge of inquiry assimilation, compromise and consensus" (Snyder and Hales, 1981, p. ii). The philosophical position that resulted was a legitimate compromise between the several "camps" in the Industrial Arts/Technology Education profession, hopefully to guide future curriculum efforts in a common direction. Snyder and Hales (1981) list the five key points in the philosophy that were established:

1. Technology education is a study of technology, industry, and their impacts (pp. 1-2).

2. The study of technology and industry is best organized around the human technical activities: communication, construction, manufacturing, and transportation (p. 23).

3. Each of the human technical endeavors is a system which has inputs, processes, outputs, feedback, and goals/restraints (p. 10).

4. Each human technical system often are developed into managed production systems (sic. p. 25).

5. Human technical endeavors are dynamic activities which have a history, present practices, and a future (p. 26).

Technology education has the basic philosophical framework to deliver the study of technology as outlined and prescribed in the Jackson's Mill Theory. It is the study of processes as well as product, where inquiry and problem-solving tie the vocational exploration to general education. It is difficult to equate any one discipline to the process of educating about technology, since technology involves social, vocational, scientific, cultural, historical, and human aspects. However, the technology education concept, if delivered properly, has the capability to present the most complete account of the wide expanse of technology (Smalley, 1987).

Recommendations to Study Technology

Along with the many reports of the early 1980's came recommendations for the study of technology, as well as the academic subjects. Boyer (1983) made at least five references to the recommendation that all students study technology. The Nation at Risk Report (1983) recommended a combined effort of the humanities, science, and technology: "Knowledge of the humanities must be harnessed to science and technology if the latter are to remain creative and humane" (p. 10). The Educating Americans for the 21st Century Report (1983) placed emphasis on technology in its course recommendation that,

> . . . A course in technology and technological thought be developed for use either at the eighth of ninth grade level. This is an appropriate time to cover subjects in technology in depth, rather than waiting until the last year of high school (p. 70).

Folks (1987) made specific recommendations to the study of Technology Education Programs in the State of Oklahoma. The Task Force on Education and Economic Development, created as a result of H.B. 1444, formulated a set of goals to move Oklahoma to the forefront in education. The recommendations required "all schools in grades seven, eight, or nine to implement the Technology Education program established by the State Department of Vocational Education" (p. 4). Folks summarized the recommendations with the statement: "We must place aside our provincialism, parochialism, and self-centeredness and say, 'Our priority is the children'" (p. 1).

Delphi Studies

The purpose of the Delphi Technique is to "obtain a consensus of opinion from a group of respondents" (Salancik, Wenger and Helfer, 1971, p. 65). The Delphi Technique was developed by the Rand Corporation during the 1950's to obtain expert opinion on how many Soviet bombs would be required to do a specific amount of damage in the United States. Since that time, the popularity of the technique has grown in the use of public policy analysis, educational innovations, program planning, and a number of other applications. Its emphasis is on developing expert consensus on a specific research topic. All action is taken via mail through three to five questionnaires. Since 1965 educational research has used the Delphi approach increasingly, until today it is a very common data gathering tool (Judd, 1972).

Hopkins, Ritter, and Stevenson (1972) found that the Delphi Technique could help the Oklahoma State Department of Vocational Education forecast the direction occupational training should take to most effectively serve Oklahoma. Smalley and Brady (1984) conducted a modified Delphi study to find some consensus from experts on the criteria for constructing a test for technological literacy for 12th grade students.

This study was modified in the sense that the responses used in the first round were predetermined from the literature rather than generated by the panel of 14 experts.

Dean (1986) conducted a three-round Delphi study to develop a listing of readiness criteria that instructors could refer to in determining whether classroom experiential learning is appropriate instruction for a specific instance. This study utilized the methodology designed by Dalkey and Helmer (1963) and Delbecq, Van deVen, and Gustafson (1975) to arrive at a consensus on the readiness criteria, with 21 experts involved.

Harritt (1987) surveyed the perceptions of vocational agriculture teachers and county agriculture extension agents about the feasibility and importance of alternatives in agriculture to help farmers and ranchers raise their economic level. Another modification of the true Delphi approach consisted of one round to solicit possible alternatives and a second round to rate the alternatives. Ideas for the questionnaire were generated through the nominal group technique or "Brainstorming" which is similar to Delphi, except the respondents have face to face meeting. A unique system of ranking the second round involved a scale of 1-99 rather than the commonly used Likert-type scale. A total of 163 respondents were asked to participate in the study.

Barnes (1987) used the Delphi Technique to identify key descriptors of a definition of technology and the appropriate curricular organizers for the study of technology. A three-round Delphi was conducted with a total of 35 panelists. The Q sort method for ranking was used to organize the data.

Research Definitions

One of the key steps in the scientific method is to clearly define the problem or situation. The purpose of this study was to identify the criteria that characterize a technologically literate individual. From these criteria, a definition of technological literacy was postulated. According to Maley (1985) it is vital that we be able to define new areas of education in clear, concise, and intelligible terms to the members of the profession, other educators, the lay community, our supporters, and the other decision-makers in education.

Definitions are necessary to provide understanding and clarification for research, curriculum planning, strategic planning, and legislation. Without a clear definition of a topic effective goals cannot be established. For example, for the purpose of clarification for the purposed legislation, H.R. 3102 - "The Technology Education Act of 1985" a definition of Technology Education was developed. The definition was stated as follows:

> . . . 'technology education' means a comprehensive educational process designed to develop a population that is knowledgeable about technology, its evolution, systems, techniques, utilization in industry and other fields, and (its) social and cultural significance (p. 2).

This definition provided a point of reference for legislative committees to work from and establish the necessary points of emphasis required in legislative debate for bill passage. Maley (1985) further suggested that a definition must be more than just words. "They must be symbols of practice in the programs conducted in the schools" (p. 4).

The review of literature produced a number of studies and articles that addressed definitions from all areas of education. The most frequent definition studies were found to be in the Applied Behavioral Sciences in reference to the handicapped and disabled programs to define those who should be served. Only one study was found to explain the method and procedure used to establish a definition. Berger (1983) used a modified duty and task analysis model to define a homosexual.

According to MacMillan (1982), a definition of technological literacy should meet three criteria. First, the criteria that must be met before an individual is considered technologically literate should be identified. Second, every technologically literate person must share the elements described in the definition. Third, those who are not considered technologically literate must fail to exhibit at least one of the elements of the definition.

Summary

The review of literature documented the multiple interpretations of the various terminologies that have been emphasized in the educational reform reports and within the profession. The many different interpretations pointed out the need for a clear consensus on the meaning of technological literacy as educators move toward program revisions. The review of literature also indicated a trend away from specific skill development and technical competence in terms of general education requirements for a technologically literate citizenry. The research reports indicated a strong emphasis upon social interaction, awareness and sensitivity toward technology, and general concepts of technological principles to better prepare for a changing future. With the numerous reports dealing with the problems of our educational system, came many recommendations for the study of technology and the call to improve technological literacy, some of which specifically assigned the area of Technology Education to teach the concepts. Because of the flexibility of the Delphi Technique and the information it can gather, it has become extremely popular in educational research. The literature revealed that the Delphi method of gathering information is an appropriate technique to reach consensus of opinion from experts as new terms and events develop, creating the need for educational change.

CHAPTER III

METHODOLOGY

The purpose of this study was to reach a consensus among recognized leaders in the fields of education, business and industry, and vocational administration as to the criteria a technologically literate person should possess. From the criteria that were identified, a definition of technological literacy was postulated. This chapter will be devoted to the method of collection and analysis of data pertaining to the purpose and objectives of the study and will be divided into the following sections: (1) Type of Research, (2) Population, (3) Instrumentation, (4) Data Collection, and (5) Analysis of the Data.

Type of Research

In regard to research design, Kerlinger (1973) has this to say:

> Research sets up the framework for 'adequate' tests of the relations among variables. Design tells us, in a sense, what observations to make, how to make them, and how to analyze the quantitative representations of the observations. Strictly speaking, design does not 'tell' us precisely what to do, but rather 'suggests' the directions of observation-making and analysis. An adequate design 'suggests,' for example, how many observations should be made, and which variables are active and which are attribute. We can then act to manipulate the active variables and to categorize the attribute variables. A design tells us what type of statistical analysis to use. Finally, an adequate design outlines possible conclusions to be drawn from the statistical analysis (p. 301).

The research design is what makes a study an effective and productive mechanism for evaluation of data. Without well structured design the results may be without value.

Information for this study was obtained using a Delphi Technique designed by Dalkey and Helmer (1963) and revised by Delbecq, Van deVen, and Gustafson (1975). The primary objective of a Delphi inquiry is to obtain a consensus of opinion from a group of respondents (Salancik, Wenger and Helfer, 1971). Delbecq, et al. further state: "Delphi is a group process which utilizes written responses as opposed to bringing individuals together" (p. 83). The group selected for this study was composed of 27 panelists from 17 states (See Appendix A). They represented the areas of business and industry, professional education and vocational administration. The experts were asked to identify the criteria that characterize a technologically literate person, then make value judgments about those criteria. The study used three mailed questionnaires, a comprehensive literature review, personal interviews, and telephone interviews. According to Key (1974), "Descriptive research is used to obtain information concerning the current status of the phemonena" (p. 126). This study used a method of descriptive research and ordinal level data to interpret group suggestions and opinions into a collection of descriptive information for decision making.

Population

During the Fall of 1986, the School of Occupational and Adult Education at Oklahoma State University began the process of revising its teacher education curriculum in the Industrial Arts area, with a goal to offer a teacher education program designed to prepare future teachers for Industrial Technology Education. As a part of this revision process, a national survey was conducted to identify the leading professional educators in the area of Industrial Arts/Technology Education (Wicklein, 1987). The top four leaders were then invited to participate in a DACUM (Developing a Curriculum) Study at Oklahoma State University. From this study a list of duties and tasks was identified to guide the curriculum changes. The survey results were used to select the experts for the professional educators panel in this study. All have contributed to the study of technological literacy and can be considered authorities based upon their research and publications.

In a similar national survey conducted by Peters (1987), State Director of Vocational and Technical Education in Oklahoma, the leading state vocational programs were identified. That study, along with the review of literature that revealed authorities based upon their research and publications, provided the basis for the selection of the panel of vocational administration. In addition to state administrators two participants from the United States Office of Education, Vocational Division were selected.

In this study, personnel directors from 11 major corporations were asked to identify representatives from business and industry to make up the panel to participate in this study. The areas represented by the panelists included banking, manufacturing, construction, aircraft engineering, medicine, personnel, marketing, trucking and music.

Because the success of the Delphi Technique relies upon the use of expert opinion, random selection was not considered. The participants that were selected are considered to be the leading authorities in their field by their colleagues, employers, and peers.

A letter explaining the purpose and objectives of the study was mailed to 28 of the experts identified in the panel selection process. Twenty-seven of the 28 agreed to participate by returning a self-addressed post card with their signature and a check-mark in the blank that indicated their willingness to be a part of the study (See Appendix B).

Instrumentation

The topic of technological literacy has become a subject of international attention (Dyrenfurth, 1987). To accomplish the purpose and objectives of this study, it was necessary to obtain the opinions of the most qualified experts in the nation. The review of literature revealed four studies (Smalley, 1984; Dean, 1986; Harritt, 1987; Barnes, 1987) that used the Delphi Technique to acquire information in similar studies involving expert's opinions. Because the Delphi is a group process using written responses from people who have opinions about a subject, and based upon the above studies, the Delphi Technique was determined appropriate for this study. Hopkins, Ritter, and Stevenson, (1972) found that the Delphi Technique was also useful as a forecasting tool to provide information for future direction of research and education. Harritt (1987) cited Helmer (1967) as using the Delphi Technique as a forecasting tool in business. According to Brockhaus and Mickelson (1977) Delphi is used primarily in applied research for the purpose of planning or forecasting.

The Delphi procedure used in this study parallels the research of Helmer (1963, 1967), Dalkey (1967), Linstone and Turoff (1973), Brooks (1979), and Foster and Koazk (1986). The doctoral dissertations of Dean (1986), Harritt (1987), and Barnes (1987) were found to be consistent with the research of the experts and provided the format of this study.

The Delphi Technique is an approach intended to elicit, and refine the opinions of a group of experts. The technique was developed by Helmer at the Rand Corporation in Southern California, in the early 1950's, to obtain group opinions about urgent defense problems, such as forecasting defense technology needs. The name Delphi comes from the Ancient Greek "Oracle at Delphi," where authorities were gathered to make important decisions. Over the past 20 years, the Delphi Technique has gained popularity in educational research. Judd (1972) found it is a valuable method in planning curriculum in higher education. Utilization of the Delphi Technique in educational settings has produced favorable results where it is not possible to assemble a group of known experts. Bloom (1979) noted while conducting research on aid to terminally ill people that the Delphi "attempts to take individual opinions and compile a meaningful response and to get an expert opinon without bringing the experts face to face" (p. 27). The most frequent of these applications in education have been in projecting future goals and gaining a consensus about a specific topic.

The Delphi Technique consists of one or more rounds of open-ended questionnaires to poll original statements from respondents, with follow-up rounds of questionnaires directing the respondents to rate their statements for importance in relation to each other (Cyphert and Gant (1971) as cited in Harritt (1987). According to Fray (1983) open-ended questions should be avoided in most survey research. However, Delbecq, et al. (1975) explained that the Delphi Technique is a systematic acquisition of opinions from a representative panel of experts who respond to one or more open-ended questions in the first contact to provide the framework for the remainder to the study. Fray (1983) also contended that a reason for using open-ended questions is "the capture of unsuspected information," (p. 2) and is valid for brief, informal questionnaires to small groups of fewer than 50 responders. In this study, the responses conveyed the overall opinions of the experts. When a number of responses are acquired, Fray further suggested that they be analyzed and placed into prevalent categories so the responders can quickly see the results. This study followed these suggestions.

Policy formulation and decision-making require two different kinds of input: factual judgment and value judgment (Dalkey, 1969). This study to identify the criteria that characterize a technologically literate person used information obtained from value judgements. According to Dalkey, the Delphi Technique is applicable for use with value judgement information:

> A fairly popular form of value judgment is the formulation of the major objectives of an organization and the weighting of these objectives on some scale....But the question of the validity of the procedures is much more obscure when value judgments are involved (1969, p. 73).

To date the Delphi has not been validated for use with information from value judgments, but the opinion from a number of representative experts have proven to be of great value to educational research.

According to Key (1988), the Delphi Technique has several distinct advantages such as a number of ideas are quickly generated, priorities of experts are expressed, personality conflicts are avoided, goals are generated and time and money are saved. Dalkey (1969) lists three primary features: (1) Anonymity, which is a method of reducing the influence of dominant individuals, (2) controlled feedback, which is a method of "conducting the exercise in a sequence of rounds, between which a summary of the results of the previous round are communicated to the participants" (p. 16), (3) statistical group response, which refers to the concept that the group of participants are defined as a single body, even though a final consensus may indicate a wide-spread of opinions among group members.

A three probe Delphi Technique was used to conduct the research for this study. The panel consisted of 27 members, nine from each of the three areas of business and industry, vocational administration, and professional education. A series of three questionnaires was mailed to the 27 experts. The first probe asked one, open-ended question: "What do you feel are the criteria, or educational concepts, that characterize a technologically literate person?" This question was generated by an advisory committee consisting of three members and the researcher. The statements from the first round provided the basis for the second questionnaire where the panel was asked to rank the 15 most essential criteria generated in Delphi I. Results from this second probe were then used to develop the third questionnaire where each panelist was asked to prioritize the essential criteria and justify their responses.

Dean (1986) cited Delbecq, et al. (1975) in relation to sample size:

> Our experience indicates that few new ideas are generated within a homogeneous group once the size exceeds 30 well chosen participants. However, the panel size is variable and a minimum number of ten to 15 is required to generate sufficient new ideas for group processing (p. 89).

The sample size of 27 fell within the range recommended by Delbecq, et al. (1975).

Collection of Data

For each round, measures were taken to prevent attrition and to increase the response rate. The Delphi I was mailed to each panelist within one week after all experts agreed to participate. Each of the three questionnaires was accompanied by a cover letter constructed to state the purpose of the questionnaire, thank the panelist, and give information. Each questionnaire was constructed with instructions and information to clarify the responses requested, as recommended by Campbell and Perry (1987). A self-addressed stamped envelope was enclosed for the return of each questionnaire, and panelists were asked to return the questionnaire within one week (Campbell and Perry, 1987). In each of the three probes, those who did not meet the deadline were contacted by telephone. To preserve anonymity, the panelists only knew that they were one of 27 experts chosen to be a part of this study. The response rate was insured by contacting each participant in advance to ask for their assistance in the study.

Delphi I asked one, open-ended question: "What do you feel are the criteria that characterize a technologically literate person?" Panelists were instructed to answer the question with as many brief and concise statements as they felt necessary. This first probe served as the beginning point for the study (See Appendix C). The experts identified 146 criteria which were sorted into 25 like criteria by a review panel.

Delphi II was constructed from the information generated in the first probe. The 25 criteria that were identified in Delphi I were randomly placed on one page. The panel was instructed to rank the 15 most essential criteria that characterize a technologically literate person, with "1" the highest and "15" the lowest. Additions and comments addressing the 25 original criteria were encouraged in space provided on the instrument (See Appendix D).

Delphi III was a refinement of the second probe. The 15 most essential criterion were listed in the rank order of the responses to Delphi II, along with the number of ranking points received. The rank that each panelist assigned in the second probe was also listed for their reference. Space was provided for comments and justification for the panelists responses (See Appendix E).

Analysis of Data

Delphi I

Analysis of the first questionnaire involved three steps. Each of the 146 responses was entered into the computer and typed onto a 3X5 index card exactly as it appeared on the Delphi I questionnaire.

The key descriptor for each of the 146 criterion was identified by a review panel composed of one college professor, two graduate students, and one public school administrator. The key descriptors were then entered into the computer to sort the responses into like categories, and each 3X5 card was grouped into the category identified by the computer.

The cards were then analyzed by the review panel to determine the similarity of the responses and correlation to the descriptor. The response with the clearest and most exact representation of the category, as determined by the review panel and the researcher, was selected to be the statement to form the basis of the second questionnaire. Twenty-six statements were identified by the computer to include all of the 146 ideas generated in Delphi I. After analysis by the reviewing panel, one statement that represented a single category was found to belong to another established category. This correction reduced the total criteria categories to 25. These 25 statements formed the basis of the second questionnaire.

Delphi II

The purpose of the second questionnaire was to determine the relative rank of the 25 criteria identified in Delphi I. Panelists were asked to select the 15 most essential criteria from the 25. They were then asked to rank those 15 from "1 to 15" with "1" being most important and "15" least important. Analysis of the responses involved a summation of favorable responses for the most important criteria. A group value was determined for each criteria by assigning a value of 15 to each "1" rank, 14 to each "2" rank and one to each "15" rank. The relative rank of a criteria that the experts chose was determined by the number of points it received from its group value. This followed the procedure outlined by Brooks (1979) and Dean (1986).

Delphi III

The purpose of Delphi III was to reach a final closure of the most essential criteria generated in Delphi I. This refinement process of the 25 original criteria directed the panel to re-evaluate the top 15 criteria determined through the second round. The priority rank that each panelist had assigned in Delphi II was listed on the survey, and the panelists were asked if they still agreed with their choice. If there was disagreement, the panelists were instructed to make changes and justify all responses (See Appendix E).

Statistical analysis consisted of three methods. Ordinal level descriptive statistics were calculated to determine the mean scores, deviation scores, and standard deviations of the criteria established in Delphi III. Raw scores were entered into the Systat Statistical program to determine the means, standard deviations, minimum and maximum values, and N for each of the criterion. By ranking the means, the list of technological literacy criterion statements could be placed in the priority rank as judged by the panelists to determine the most essential components for a definition. This analysis was also used to determine the amount of agreement each group of experts had for each of the criterion, and to determine which group or groups deviated the most from the panel as a whole.

The Kendall Coefficient of Concordance (W) was used to determine the degree of association among the experts on Delphi III. According to Siegel (1956), the Kendall (W) is a type of correlational test useful in determining the extent of agreement among judges on a number of issues. It was calculated by finding the rank sum of all judges (panelists) on each issue expressed as a deviation. The mean was then calculated and the deviations squared. The null hypothesis for the Kendall (W) was:

Ho: The rankings by the individual experts are unrelated.

Statistical testing of the Delphi Technique is severely limited because of value judgments instead of factual quantitative data. Dalkey (1969) addressed this limitation by stating:

> . . . the question of the validity of the procedures is much more obscure when value judgments are involved. The prevailing opinion at the present time appears to be that there is no clear sense in which value judgments can be said to be true or accurate. Hence, it is of practical

> importance to ask whether there is any objective way to test Delphi procedures in the value area (p. 73).

However, Delbecq et al. (1975) contend that the Delphi Technique is a consensus of opinions, and since the source of the information was from a representative sample of experts from across the nation, the consensus of opinions have value and fulfill the purpose of this study in compiling a list of criteria for reference.

The Kruskal-Wallis one-way analysis of varience test was used for the final statistical analysis of the Delphi III data to determine the differences among the rank scores of the three groups of experts. The resulting H value, when compared to the critical value found in the appropriate Chi Square Table, indicated any differences of opinion of the experts among the groups. The Kruskal-Wallis Test and the Kendall Coefficient of Concordance (W) were used to analyze the data to answer research question number three and determine if final closure had been reached by the experts to the agreement of the essential criteria necessary for a definition of technological literacy.

Research Question Number Four posed the question: "What is a definition of technological literacy based upon the criteria established?" To postulate a definition it was necessary to prioritize the criteria to determine the essential components for a definition. Through the Delphi Technique the essential criteria were identified and prioritized (ranked) by a panel of 27 experts representing business and industry, vocational administration, and professional educators.

CHAPTER IV

PRESENTATION OF FINDINGS AND ANALYSIS OF DATA

In order to postulate a definition of technological literacy, it was necessary to determine the criteria that characterize a technologically literate person and identify the most essential components for the definition. Through the refinement process that the Delphi Technique provides, these criteria were identified, and a value for each was judged by the panel of experts through a series of three mailed questionnaires. These criteria, then, became the premise for a definition of technological literacy.

This chapter is devoted to the presentation of the findings in relation to the research questions, as well as additional information, as stated in Chapter I. The presentation of findings and analysis of the data is arranged with the results of each of the Delphi probes. Information about the response data, comments and justification for the panelist's choices, and the analysis procedures are included for each probe. The criteria that was generated by the panel of experts is presented with an explanation of the identification process and ranking results. The final section presents the findings of the analysis of the third probe (Delphi III) where the criteria was given a final priority rank. This section also describes the differentiation of rankings by the three expert groups.

Response Data

Delphi I

Research Question Number One. What are the criteria that characterize a technologically literate person?

This open-ended question allowed the participants to respond freely without limitations. The instrument was designed to obtain information to establish the criteria that characterize a technologically literate person, therefore, all responses were considered important. The instrument and cover letter was mailed March 10, 1988, with a request to return the completed questionnaire by March 18, 1988. The cover letter asked the panel to identify the criteria that they felt characterize a technologically literate person, and included an explanation of the purpose of the study (See Appendix C).

Twenty-one of the 27 panelists responded within the requested time periods, and four more responses were received the following week. After follow-up requests by telephone, the two remaining panelists responded, for a 100 percent return on Delphi I.

A total of 146 criteria (See Appendix F) was generated by the panel. Through a computer analysis, the key descriptors (Table I) of the criteria were sorted into 26 categories of like responses. After a review panel of four persons analyzed the 26 categories, one response was found to have the qualities of an existing category which reduced the total to 25. Four of the panelists included statements to explain and verify their choice of ideas. Four of the panelists sent materials that they had developed on the topic of technological literacy. A list

TABLE I

KEY DESCRIPTORS USED TO GROUP QUESTIONS

Criterion	Key Descriptors
1.	Global competition
2.	Personal limits
3.	Engineering design
4.	Decision-making
5.	Problem solving
6.	Continuing Education
7.	Adapt to change
8.	Culture
9.	Evaluate
10.	Communicate/terminology
11.	Technical processes
12.	Information resources
13.	Scientific principles
14.	Thinking
15.	Emerging processes
16.	Use artifacts
17.	Creative skills
18.	Democratic process
19.	Environment/society
20.	Choosing technologies
21.	Character
22.	Careers
23.	Past events
24.	Human values
25.	Unfamiliar process

of the 25 criteria can be found in Table II.

Two of the respondents listed their criteria in order of importance, from simple to complex. One respondent made an effort to arrange the criteria in progression from technical literacy toward technical proficiency, with the belief that they represented a continuum of increased complexity.

Delphi II

Research Question Number Two. What is the relative importance of each of the technological literacy criteria?

The responses that identified the criteria in Delphi I, provided the design for the second questionnaire. The purpose of the second probe (Delphi II) was to prioritize the 25 criteria generated in Delphi I to determine the relative importance of each. It also allowed the panel the opportunity to generate additional criteria which was not considered in the first probe. Even though this option was given, there were no additions to the 25.

The second probe was mailed April 1, 1988. The cover letter (See Appendix D) explained the procedure used to determine the 25 criteria that made up the Delphi II instrument. Panelists were asked to: (1) indicate the 15 most important criteria with a check mark, (2) rank the 15 most essential criteria on a scale of one through 15, with "1" being the most important, (3) add new criteria and make comments to justify their selection, and (4) return the instrument by April 11, 1988.

All of the 27 panelists responded to Delphi II for a 100 percent return rate. Twenty of the panelists responded before the requested

TABLE II

CRITERIA THAT CHARACTERIZE A TECHNOLOGICALLY LITERATE PERSON

Synopsis of Delphi I Responses

Understands the impact of global competition.

A knowledge of one's personal limits when dealing with technology.

Understanding of engineering design.

Understand and apply decision-making and cost justification processes.

Able to identify a technological problem, gather information for solving the problem, analyze the system (synthesis) to find a solution, and understand the scientific approach to evidence.

Knows that continuing education is important.

Able to understand and adapt to change brought about by technology with an open mind.

One who has achieved culture. (Greek: paideia)

The ability to evaluate a technological process or product in terms of the personal, economic, and societal benefits of its applications.

Understanding of the specific technological terminology . . . and the ability to read, interpret, and communicate the terminology to all levels - from workers to managers.

An awareness of key technical processes and the principles behind them. (eg. how things work)

Knowledge of technological information resources and locations so one can access technical information.

Understands and proficient in the application of scientific principles upon which technology is based.

Recognize the contributions that innovative thinking, abstract thinking, and critical thinking produces for technology.

Awareness of key existing and emerging technological processes and their impact on the workplace and society.

Ability to use technological artifacts (tools, machines, materials, and processes) commensurate with one's social and occupational role in life.

TABLE II (Continued)

Synopsis of Delphi I Responses
Understand and have the ability to develop creative skills, and be open to "doing things differently."
Understands and participates in the democratic process involving issues that pertain to science and technology, public policy, and legislation.
Awareness of evolving technologies, and be able to predict possible impacts upon environment, society, human concerns, and individuals.
Understanding related to the benefits and risks of choosing technologies.
Must have character to accept counsel or criticism, ambition and desire to accomplish, and be able to develop self-confidence and not be discouraged by failure.
Insight as to the relationship between careers and the technological future.
Connect past technological events to the present, and be able to project alternative futures.
Understand the interactions and effects of science and technology on society, and human values of ethics and morality.
Ability to conceptualize how an unfamiliar technological process or machine operates.

date, five additional responses were received within the next five days, and the remaining two panelists responded immediately after a follow-up contact by telephone.

One panelist in the business and industry group ranked all 25 of the criteria and justified his response by stating, "Some of the items are important, but lack depth to be counted as major." Only the criteria ranked one through 15 were considered in the analysis. The 15 most essential criteria were checked as instructed by the panelist.

Another panelist in the professional educators group did not place a rank for any of the 25 criteria. The 15 most essential items, however, were checked. The rationale was justified by the statement, "I think that all of these 15 are of equal importance. Remove any of them and you are technologically illiterate." Although the panelist did not rank the criteria, the selection of the 15 most essential criteria was a correct procedure. In the analysis, the 15 criteria selected were counted, but points were not assigned in the ranking.

Ranking points were determined by a point system which assigned 15 points for a ranking of "1", 14 points for a ranking of "2", etc. This procedure allowed the 25 criteria to be placed in a priority rank to determine the most essential criteria. The frequency of selection for each item was used to establish the priority rank in case of ties. The priority rankings of the 25 criteria are shown in Table III along with the frequency of selection.

The most essential criterion identified in Delphi II was "Understanding of the specific technological terminology . . . and the ability to read, interpret, and communicate the terminology to all levels - from workers to managers." Although criteria two, three, and five had a

TABLE III

DELPHI II PRIORITY RANK OF CRITERIA

Frequency	Rank Points	Rank	Criteria
19	225	1.	Understanding of the specific technological terminology . . . and the ability to read, interpret, and communicate the terminology to all levels - from workers to managers.
20	215	2.	Able to identify a technological problem, gather information for solving the problem, analyze the system (synthesis) to find a solution, and understand the scientific approach to evidence.
20	204	3.	An awareness of key technical processes and the principles behind them. (eg. how things work)
19	181	4.	Knowledge of technological resources and locations so one can access technical information.
21	168	5.	Able to understand and adapt to change brought about by technology with an open mind.
15	137	6.	Awareness of evolving technologies, and be able to predict possible impacts upon environment, society, human concerns, and individuals.
18	134	7.	Understand the interactions and effects of science and technology on society, and the human values of ethics and morality.
17	132	8.	Ability to use technological artifacts (tools, machines, material, and processes) commensurate with one's social and occupational role in life.
15	131	9.	The ability to evaluate a technological process or product in terms of the personal, economic, and societal benefits of its applications.

TABLE III (Continued)

Frequency	Rank Points	Rank	Criteria
15	124	10.	Awareness of key existing and emerging technological processes and their impact on the workplace and society.
11	124	11.	Knows that continuing education is important.
15	121	12.	Understands and is proficient in the application of scientific principles upon which technology is based.
16	120	13.	Understands and has the ability to develop creative skills, and be open to "doing things differently."
16	119	14.	Recognize the contributions that innovative thinking, abstract thinking, and critical thinking produces for technology.
17	97	15.	Connect past technological events to the present and be able to project alternative futures.
12	89	16.	Understands and participates in the democratic process involving issues that pertain to science and technology, public policy, and legislation.
14	81	17.	Ability to conceptualize how an unfamiliar technological process or machine operates.
11	78	18.	Understanding related to the benefits and risks of choosing technologies.
13	69	19.	A knowledge of one's personal limits when dealing with technology.
11	69	20.	Must have character to accept counsel or criticism, ambition and desire to accomplish, and be able to develop self-confidence and not be discouraged by failure.
11	64	21.	Understands the impact of global competition.
5	52	22.	Understand and apply decision-making and cost justification processes.

TABLE III (Continued)

Frequency	Rank Points	Rank	Criteria
6	29	23.	Insight as to the relationship between careers and the technological future.
6	27	24.	Understanding of engineering design.
1	15	25.	One who has achieved culture. (Greek: paideia)

higher frequency of selection, the business and industry representatives all ranked the number one criterion one, two, or three to account for the higher number of rank points.

Out of a possible 27, the frequency of selection ranged from one to 21 of the total 25 criteria. The number five criterion, "Able to understand and adapt to change brought about by technology with an open mind," was selected 21 times indicating its popularity, with 168 rank points for its priority rank. The frequency of selection in the first 15 criteria ranged from 11 to 21.

Two sets of ties existed in the priority ranking. In the case of ties, the criterion with the highest frequency of selection was ranked higher. Criterion 10 and 11 each received 124 ranking points, with criterion 10 receiving 15 votes and criterion 11 receiving 11 votes respectively. Criterion 19 and 20 each received 69 ranking points. The frequency of selection determined the priority rank with criterion 19 receiving 13 votes and criterion 20 receiving 11 votes.

Although criterion number 12, "Understands and is proficient in the application of scientific principles upon which technology is based," was ranked as one of the 15 most essential criteria, two experts argued that the wording indicated that technology is simply applied science and refers to scientific literacy; not technological literacy. The frequency of selection indicated that 15 of the 27 experts had selected this criterion.

Delphi III

The purpose of the third questionnaire was to reach a final closure of the most essential criteria for a definition of technological literacy, and answer Research Question Number Three: "Do business and industry representatives, professional educators, and vocational administrators rank the technological literacy criteria differently?" The final probe was mailed April 26, 1988, with a cover letter asking the panel to (1) examine the 15 criteria that had been prioritized in Delphi II, (2) determine if there was still agreement with their Delphi II choice, (3) change the ranking if they did not agree, (4) rank these 15 criteria by assigning a "1" to the most essential, "2" for the second, ect., (5) make comments to justify their choices and (6) return the instrument by May 6, 1988. Enclosed with the instrument was a complete report of Delphi II with a listing of the 25 criteria that were ranked and the frequency of selection as noted in Table III.

The questionnaire was designed similarly to the second questionnaire. The results of Delphi II provided the design, with the 15 most essential criteria ranked by the points received. The instrument also provided the panelists with the rankings that they assigned to the criteria in Delphi II for a reference. (See Appendix F) The unique advantage of the Delphi Technique allows the panelists to justify their choices. Space was placed beside each criterion for the panelist to make comments to express their thoughts and justify the reason for their decision. Twenty-six of the panelists returned the survey by the May 6, target date; The final survey was received May 10, 1988, to make a 100 percent return on Delphi III. The priority ranking of the third and final probe can be found in Table IV.

The same panelist who did not rank the 15 criteria in Delphi II again argued that each of the criterion was equally important. He justified his decision with the example: "Which is the most important

TABLE IV

DELPHI III FINAL RANKING OF CRITERIA

Delphi II Rank	Rank Points	Delphi III Rank	Criteria
1	359	1.	Understanding of the specific technological terminology . . . and the ability to read, interpret, and communicate the terminology to all levels - from workers to managers.
2	333	2.	Able to identify a technological problem, gather information for solving the problem, analyze the system (synthesis) to find a solution, and understand the scientific approach to evidence.
3	308	3.	An awareness of key technical processes and the principles behind them. (eg. how things work)
5	284	4.	Able to understand and adapt to change brought about by technology with an open mind.
4	257	5.	Knowledge of technological resources and locations so one can access technical information.
6	255	6.	Awareness of evolving technologies, and be able to predict possible impacts upon environment, society, human concerns, and individuals.
7	223	7.	Understand the interactions and effects of science and technology on society, and the human values of ethics and morality.
9	218	8.	The ability to evaluate a technological process or product in terms of the personal, economic, and societal benefits of its applications.
8	193	9.	Ability to use technological artifacts (tools, machines, material, and processes) commensurate with one's social and occupational role in life.

TABLE IV (Continued)

Delphi II Rank	Rank Points	Delphi III Rank	Criteria
10	155	10.	Awareness of key existing and emerging technological processes and their impact on the workplace and society.
11	137	11.	Knows that continuing education is important.
12	135	12.	Understands and is proficient in the application of scientific principles upon which technology is based.
13	111	13.	Understands and has the ability to develop creative skills, and be open to "doing things differently."
14	79	14.	Recognize the contributions that innovative thinking, abstract thinking, and critical thinking produces for technology.
15	73	15.	Connect past technological events to the present and be able to project alternative futures.

side of a triangle?" Because the expert did not follow the correct procedure, it was not possible to include the survey information in the final tabulation of the rank of the criterion. He did, however add that he felt criterion number one was of vital importance to all of education, "Without proper communication between departments, the real meaning of technology and technological literacy will never be fully understood."

All but two of the panelists ranked criterion number one (Understanding of the specific technological terminology . . . and the ability to read, interpret, and communicate the terminology to all levels -- from workers to managers) as the first, second or third priority. Comments to justify this as the most essential criterion included references to all of education, on-the-job communication, as well as adaptation to new technologies. One panelist seemed to sum all of the comments with the statement, "Without effective communication, technological literacy will lose its sense of value."

One panelist indicated that criterion number five might well be included as a part of criterion number two. The comment was:

> Since problem solving very often includes research it might be proper to list criterion five (Knowledge of technological resources and locations so one can access technical information) as a second part of the second criterion where gathering information to solve the problem is mentioned (np).

The criterion receiving the most comments was number three: An awareness of key technical processes and the principles behind them (eg. how things work). All of the comments were highly favorable and supportive of the need to know the basic principles of how systems can work together. One panelist noted, "To be technologically literate one must have at least a basic knowledge of the working principles of machines even if it is only the lever, wedge, and wheel."

Four criterion ranked in the Delphi II process were assigned different priority ranking by the panelists in Delphi III. Statements, that were ranked four and five in Delphi II were interchanged by the panel, placing "Able to understand and adapt to change brought about by technology with an open mind," as the number four criterion, and "Knowledge of technological resources and locations so one can access technical information," as the number five criterion. In regard to change and technology, one panelist argued that "The basic philosophy underlying technology is change; without change there would be no technology." Criterion that were ranked eight and nine in Delphi II were also interchanged by the panel in Delphi III. In the final probe the panelists felt "The ability to evaluate a technical process in terms of the personal, economic, and societal benefits of its application," should be the eighth most essential criterion and "The ability to use technological artifacts (tools, machines, materials, and processes) commensurate with one's social and occupational role in life," should be moved to criterion number nine. The most significant statement in reference to number eight was concerned with consumer knowledge: "At some point in the education process we must teach something about consumer economics - information about how to make wise decisions and evaluate the process or product in regard to its benefit vs. cost."

Although criterion number 11 which emphasized continuing education was ranked favorably, one expert in the professional educators group felt it was not a part of technological literacy. The justification was, "If one is to succeed in life, the process of education is never finished. This statement is a given fact of life." Table V shows that

TABLE V

PRIORITY RANK OF CRITERIA BY EXPERT CATEGORY

Bus. Ind. Rank	Prof. Ed. Rank	Voc. Adm. Rank	Total Rank (Based on Points)
1	3	1	1. Understanding of the specific technological terminology . . . and the ability to read, interpret, and communicate the terminology to all levels - from workers to managers.
2	1	3	2. Able to identify a technological problem, gather information for solving the problem, analyze the system (synthesis) to find a solution, and understand the scientific approach to evidence.
4	2	2	3. An awareness of key technical processes and the principles behind them. (eg. how things work)
6	6	4	4. Able to understand and adapt to change brought about by technology with an open mind.
3	5	5	5. Knowledge of technological resources and locations so one can access technical information.
5	4	6	6. Awareness of evolving technologies, and be able to predict possible impacts upon environment, society, human concerns, and individuals.
9	8	7	7. Understand the interactions and effects of science and technology on society, and the human values of ethics and morality.
11	9	8	8. The ability to evaluate a technological process or product in terms of the personal, economic, and societal benefits of its applications.
7	7	10	9. Ability to use technological artifacts (tools, machines, material, and processes) commensurate with one's social and occupational role in life.

TABLE V (Continued)

Bus. Ind. Rank	Prof. Ed. Rank	Voc. Adm. Rank	Total Rank (Based on Points)	Criteria
13	10	9	10.	Awareness of key existing and emerging technological processes and their impact on the workplace and society.
8	15	12	11.	Knows that continuing education is important.
12	11	11	12.	Understands and is proficient in the application of scientific principles upon which technology is based.
10	12	13	13.	Understands and has the ability to develop creative skills, and be open to "doing things differently."
14	13	15	14.	Recognize the contributions that innovative thinking, abstract thinking, and critical thinking produces for technology.
15	14	14	15.	Connect past technological events to the present and be able to project alternative futures.

the professional educator's as a group ranked this criterion as number 15; the least important criterion.

Criterion 12 through 15 received very few comments to justify the panelists choices. The comments that were noted, however, were in favor of the criteria and suggested the statements were a valid part of the technological literacy definition. Two panelists made specific reference to the criteria and its application in a definition. One statement summarized:

> I think a definition for technological literacy is long overdue. May I suggest that your definition be general enough to include all of the concepts the criteria identified, yet specific enough to give educators the direction to develop teaching objectives (np).

Research Question Number Three

Do business and industry representatives, professional educators, and vocational administrators rank the technological literacy criteria differently?

In the selection process of the panel of experts, three groups were purposively selected. The three groups were composed of nine members each from the categories of business and industry, professional educators, and vocational administrators for a total of 27 panelists in the study. To answer research question number three, the Delphi III responses from each group were tabulated and analyzed. According to Dalkey (1969) statistical analysis to test significant differences between the three groups is limited due to the small numbers of subjects in each group.

The ranking differences between the three groups are shown in Table V. The ranking priority of the criteria for each group was determined by adding the ranking points for each criterion. The information in Table V provides a reference to the raw data and is intended to give a comparison of the rank order assigned by each group in relation to the points each criterion received.

To verify the priority ranking of the raw data found in Table V, the raw scores were entered into the Systat statistical program to determine the rank means, standard deviations, minimum and maximum values assigned and N for each of the criterion. The priority rank determined by the mean value did not alter the ranking that was shown in Table V. The total group rank mean scores, standard deviations, and each group's deviation from the total group rank mean are presented in Table VI. The table shows the group ranking mean for each of the 15 criterion prioritized by the experts in Delphi III. The mean deviation scores for each group are shown in the columns under each group heading to indicate the amount of mean deviation each group had from the total group mean. Finally, the standard deviations from the total group rankings are shown for each of the criterion. This expression of central tendency in Table VI shows the diversity of ranking by the panelists.

The standard deviation scores indicated that criterion number 14 (1.73) had the lowest standard deviation from the total group mean with criterion one (2.01) and 15 (2.35) next in value. These lower standard deviation scores indicate criterion 14, 1, and 15 had the least diversity in the ranking. Criterion number nine had the greatest standard deviation (3.40) in the total group ranking. It can also be noted that criterion seven (3.11), Criterion 11 (3.17) and criterion 12 (3.19 had some diversity in the total group ranking.

Table VI also shows the mean deviations of the three groups from

TABLE VI

INDIVIDUAL GROUP MEAN DEVIATION SCORES

Criterion Rank Order	Total Group Rank Mean	Deviation from total group mean: Voc. Adm. Group	Prof. Ed. Group	Bus. Ind. Group	Total Group STD. Deviation
1.	2.15	-.04	.85	-.59	2.01
2.	3.19	.07	-.94	-.97	2.63
3.	4.15	-.59	-.26	.41	2.46
4.	5.07	.15	1.18	2.04	2.54
5.	6.19	1.42	.20	3.09	2.95
6.	6.20	.15	-.81	.82	2.54
7.	7.42	-1.75	-.99	1.14	3.11
8.	7.62	.16	.26	2.38	2.65
9.	8.58	.36	-2.33	-.36	3.40
10.	10.04	-2.04	1.09	1.07	2.94
11.	10.73	.06	1.77	-2.17	3.17
12.	10.81	.08	.44	-.48	3.19
13.	11.73	1.05	-.23	-2.06	2.84
14.	12.96	.37	-.58	-.29	1.73
15.	13.19	.31	.81	.37	2.35

the total group mean of the 15 criteria. The business and industry group deviated more than two points from the ranking mean on five of the criterion. The vocational administrator group had the greatest consistency of agreement indicated by the smallest amount of deviation from the group means.

Two significant factors indicated that the panelists placed the greatest emphasis on the criterion ranked one through nine. The total group mean score ranking produced a natural break between criterion nine (8.58) and ten (10.04). A second indicator relates to the relatively few number of comments by the panelists to justify their ranking of the criterion ten through 15. A total of eight comments were made from the 26 panelists for these last five criterion compared to a total of 119 comments for criterion one through nine.

Further analysis of the data in Table VI indicated that the mean scores of criterion five (6.19) and criterion six (6.20) were 1/100th point from a tie. When compared to the ranking points of 257 for criterion five and 255 for criterion six found in Table IV, the panelists judged the two criterion to be nearly equal in the final priority rank. The rank sums total of the two criterion found in Table VII further verify the closeness.

The Kendall Coefficient of Concordance: (W) was used to measure the relationship of judge's rankings of the various criteria. According to Siegel (1956), it is useful in determining the agreement among several judges or the association among three or more variables. "It has special applications in providing a standard method of ordering entities according to consensus when there is available no objective order of the entities" (p. 239). Although the Kendall (W) does not recognize agree-

TABLE VII

PRIORITY RANK OF CRITERIA BY PANELISTS

Panel-ist	15 MOST ESSENTIAL CRITERIA 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	1	3	4	5	2	6	7	9	8	10	11	12	13	14	15
B	1	2	3	4	5	7	6	9	8	10	11	12	13	14	15
C	2	8	3	6	7	5	10	11	1	9	12	4	13	14	15
D	2	3	1	5	4	9	7	8	6	10	12	11	13	14	15
E	1	2	3	4	5	6	7	8	11	9	10	12	13	14	15
F	1	4	7	2	8	5	3	6	10	9	13	14	11	15	12
G	1	3	2	5	4	8	6	10	7	9	15	11	13	14	12
H	1	2	4	12	6	7	14	9	8	3	5	15	13	10	11
I	9	8	5	10	6	2	1	4	11	3	13	7	14	15	12
J	1	3	2	4	5	6	7	9	8	11	10	12	13	14	15
K	3	1	7	4	15	2	9	5	14	13	8	12	6	11	10
L	2	3	6	1	8	12	7	9	15	11	4	13	5	10	14
M	1	5	2	4	6	7	10	3	11	12	13	9	8	14	15
N	1	2	11	4	8	14	13	12	6	15	3	7	5	9	10
O	1	12	2	3	9	4	11	7	13	5	8	6	10	15	14
P	2	1	3	4	5	6	7	9	8	10	11	12	13	14	15
Q	1	2	5	4	3	6	8	9	7	11	10	13	12	14	15
R	2	1	3	4	5	6	7	11	8	12	10	9	15	13	14
S	3	1	2	4	7	5	6	8	10	9	14	15	11	12	13
T	8	2	3	6	7	5	12	4	1	14	15	13	9	10	11
U	2	1	7	6	3	4	8	5	10	9	14	11	13	12	15
V	1	2	8	7	12	6	5	4	13	9	11	3	15	14	10
W	3	4	7	11	8	5	1	2	9	13	15	10	14	12	6
X	2	5	3	4	1	6	7	9	8	11	10	15	12	13	14
Y	3	2	1	6	7	6	8	9	4	14	10	11	13	12	15
Z	2	1	4	3	5	7	6	9	8	10	11	12	13	14	15
Rank Sums	57	83	108	132	161	162	193	198	223	261	279	281	295	337	343

Rank Sums Total	3113
Rank Sums Mean	207.53
Kendall (W)	.605
Chi Square Value	220.22
Critical Value at	.001 = 36.12 df = 14

ment within each of the three groups, it does show that there was strong individual agreement on the rankings of the 15 most essential criteria. Table VII shows the priority rank of criteria by the panelists and the rank sums data necessary to compute the Kendall (W) statistic.

A Kendall Coefficient of Concordance (W) test was applied to 15 criteria identified and ranked by the 26 panelists to test the null hypothesis: "There is no relationship between the individual panelists ranking of the 15 most essential criteria." The resulting W statistic (W =.605) when computed to a Chi Square value was statistically significant (x^2 =220.22, df=14, p<.001). A Chi Square value equal to or greater than 36.12 was required to be significant at the .001 level. Therefore, the null hypothesis was rejected. This Chi Square value indicated a strong relationship among the individual panelist's ranking of the 15 most essential criteria for a definition of technological literacy.

The purpose for using the Kendall (W) was to test the overall agreement by all of the panelists on the most essential criteria. Siegel (1956) emphasized that a high or significant value of (W) does not mean that the criterion that were identified and ranked are correct, but it does show that all of the judges agree in their use of the criterion.

The third research question was concerned with the differences in priority rank assigned by the three groups. The null hypothesis was tested at the .05 level of significance: There is no difference among the mean scores of the business and industry group, professional educator group, and vocational administrator group ranking of the technological literacy criteria.

A Kruskal-Wallis one-way analysis of variance test was performed to test the null hypothesis at the .05 level of significance. The H was not statistically significant ($H = .02$, $df=2$, $p<.05$). Since the observed H value of .02 does not exceed the critical value of 5.99, the researcher failed to reject the null hypothesis. Therefore, the differences among the rank scores of the groups of vocational administrators, professional educators, and business and industry representatives do not vary significantly. Table VIII presents the data necessary to compute the Kruskal-Wallis Test. The mean score and its overall rank for each criterion appear in each group category along with the rank sums for each group.

The results of the three statistical analyses indicated a very strong agreement between the three groups that the criteria ranking was valid and the three groups did not differ in their judgements of the criteria. The criteria that was identified and ranked by the panel could then be considered valid to postulate a definition.

TABLE VIII

DATA TABLE: KRUSKAL-WALLIS TEST

Criterion	Voc. Adm.		Prof. Ed.		Bus.-Ind.	
	Mean Score	Rank	Mean Score	Rank	Mean Score	Rank
1.	2.11	2	3.00	5	1.56	1
2.	3.89	8.5	2.25	4	2.22	3
3.	3.56	7	3.89	8.5	4.56	10
4.	5.22	12	6.25	16.5	7.11	21
5.	4.78	11	6.0	15	3.11	6
6.	6.33	18	5.37	13	7.0	20
7.	5.67	14	6.63	19	8.56	27.5
8.	7.78	22	7.88	23	10.0	30
9.	8.22	25.5	6.25	16.5	8.22	25.5
10	8.00	24	11.13	34	11.11	33
11.	11.33	36	12.5	40	8.56	27.5
12.	10.84	32	11.25	35	10.33	31
13.	12.78	42	11.5	37	9.67	29
14.	13.33	43	12.38	38.5	12.67	41
15.	13.5	44	12.38	38.5	13.56	45
Rank Sums		341		343.5		350.5

N = 45
H = .02
Critical Value at .05 = 5.99, df=2

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Problem

Since the Nation at Risk Report (1983) there have been numerous studies addressing educational reform and attempts to improve our educational system. Pervasive throughout these reform movements has been the importance of the study of technology as an essential element for a technologically literate citizenry. All areas of education, including math, science, music, social science, art, technology, special education, and business refer to technology and the understanding of its application. Because of the wide spread use of the term, the literature indicated there are many interpretations of the definition of technological literacy. The problem relates to the need to clearly define the concept of technological literacy.

Purpose

The purpose of this study was to identify the essential criteria that characterize a technologically literate person. Through the Delphi Technique, the essential criteria were identified and prioritized by a group consensus of the panelists. A definition of technological literacy was then postulated from the most essential criteria identified.

Four research questions were posed to guide the study. The questions were intended to begin with a broad, general concept and move the study toward a specific goal to pin-point the most essential criteria for the definition. The four research questions were:

1. What are the criteria that characterize a technologically literate person?

2. What is the relative importance of each of the technological literacy criterion.

3. Do business and industry representatives, professional educators, and vocational administrators rank the technological literacy criteria differently?

4. What is a definition of technological literacy based upon the criteria established?

Procedure

A Delphi Technique with 27 panelists was used to obtain the information necessary to answer the research questions. The panelists were chosen through a nation wide search and represented the areas of business and industry, professional education, and vocational administration. Through a series of three probes, the panelists identified and prioritized the criteria that characterize a technologically literate person. The first probe, Delphi I, asked one, open-ended question to generate a listing of the criteria and answer research question number one, "What are the criteria that characterize a technologically literate person?" The panelists were asked to respond with as many clear, concise statements that they felt necessary to answer the question.

All 27 panelists responded to the first probe and identified 146 criteria that they felt necessary to characterize a technologically literate individual. Through a computer analysis and the examination by a review panel, the original 146 statements were analyzed and sorted into 25 categories by identifying the key descriptor in each of the criterion. These 25 criteria provided the format for the Delphi II survey.

To verify the 25 criteria, the panelists were asked to select the 15 most essential criteria and rank those 15 to determine their relative importance. The panelists were also instructed to make comments to justify their choices and add any other criteria they felt should be included in the list. The Delphi II survey had a 100% return rate, with the panelists giving a priority rank to the 25 criteria to identify the 15 most essential. There were no new criteria introduced in Delphi II, therefore the 25 criteria established in Delphi I were considered valid for the study. The 15 criteria that were prioritized in Delphi II became the source for the third and final probe.

The purpose of Delphi III was to reach a final consensus by the panel of experts to identify the most essential criteria for a definition of technological literacy and answer Research Question Number Three: "Do business and industry representative, professional educators, and vocational administrators rank the technological literacy criteria differently?" All 27 of the panelists responded. However, there was one invalid survey form, which made a total of 26 panelists involved in the final probe.

The statistical analysis revealed there was strong agreement by the panelists on the ranking of the 15 most essential criteria. The analysis also indicated that the panelists placed most emphasis upon the criterion ranked one through nine. For the purpose of developing a definition for technological literacy, it was necessary to identify the criteria, or essential components, prioritize the statements, and arrive at a group consensus to validate the statements. The nine criteria are listed below in the order of importance assigned by the panelists:

1. Understanding of the specific technological terminology . . . and the ability to read, interpret, and communicate the terminology to all levels - from workers to managers.

2. Able to identify a technological problem, gather information for solving the problem, analyze the system (synthesis) to find a solution, and understand the scientific approach to evidence.

3. An awareness of key technical processes and the principles behind them. (eg. how things work)

4. Able to understand and adapt to change brought about by technology with an open mind.

5. Knowledge of technological resources and locations so one can access technical information.

6. Awareness of evolving technologies, and be able to predict possible impacts upon environment, society, human concerns, and individuals.

7. Understand the interactions and effects of science and technology on society, and the human values of ethics and morality.

8. The ability to evaluate a technological process or product in terms of the personal, economic, and societal benefits of its applications.

9. Ability to use technological artifacts (tools, machines, materials and processes) commensurate with one's social and occupational role in life.

Summary of Findings

The following results were obtained upon completion of the analysis of the data:

1. The panelists generated 146 criteria that characterize a technologically literate person.

2. The 146 criteria were reduced to 25 criteria by computer analysis and examination by a review panel.

3. The 25 criteria were further refined by the panel of experts and prioritized into 15 criterion.

4. A consensus of the panelists was reached on the priority rank of importance of the 15 criteria.

5. The three groups of panelists did not differ significantly in their choices of the criteria rankings.

6. Of the 15 criteria that were judged to be most important, one through nine were given the most emphasis.

7. Knowledge and background of concepts were judged to be more essential than specific skill development.

8. Communication and problem solving skills were judged to be the most essential characteristic of technological literacy.

9. Adaption to change in technologies and the interaction with environment, society, economic benefits, and human values of ethics and morality were judged to be essential.

10. The criteria identified were found to be similar to those suggested by Smalley and Brady (1984).

Conclusions

The following conclusions were drawn based upon the interpretation of the findings of this study:

1. Based upon the findings that only one of the 15 criteria identified related to psychomotor skills, it can be concluded that the criteria that characterize a technologically literate person should be general in nature, with less emphasis upon specific skill development.

The results of this study clearly indicate the need to emphasize technological concepts, communication and problem-solving skills, and the relationship of technological principles to society, the environment, economic benefits and the human values of ethics and morality. The finding is in agreement with the studies of Barnes (1987), Ballistreri (1988), Smalley (1984), and Cutcliffe (1981). To further support the premise, the recommendation by Boyer (1983) for all students to study technology emphasizes the generalization of technological concepts and places less emphasis on specific skill development.

2. Although the literature revealed many interpretations and the uncertainty about the meaning of technological literacy, professional educators, vocational administrators, and representatives from business and industry do in fact perceive the criteria for a definition of technological literacy to be the same (Table VII), therefore, progress should proceed with haste to develop programs that can promote technological literacy.

The outcome of this study was a consensus of agreement by the panel of experts that the criteria identified and prioritized through the Delphi process was judged to be appropriate for a definition.

Dyrenfurth (1987) indicated that many states have not moved forward with program revisions to address technology and technological literacy due to the uncertainty of what should be included. The consensus of opinion in this study can be considered one more advancement for the profession in program revision and the criteria that should be incorporated. The time is right, the issue is clear, the support is there for the profession to move forward, before some other less central area in the school may take up the banner and run with it (Maley, 1985).

3. Based upon the nature of the criteria identified (See Table V), it can be concluded that certain scientific principles can help explain the technological concepts which are a part of technological literacy.

The panel of experts strongly agreed that the scientific approach to evidence in solving problems and the interactions and effects of science and technology are essential components for a definition of technological literacy. The research by DeVore (1987) noted the many inconsistencies and confusions on the use of the terms science and technology, and he concluded that technology is not science; it is one of the sciences and the two must work together even though the terms do not mean the same. This same opinion was shared by the panel of experts in their comments to justify their decisions in the Delphi process.

4. Based upon the findings of this study which reveal a changing nature of the control of technology programs, it can be concluded that there is a need to educate future teachers and update practicing teachers to deal with the issues related to a changing technology and its relationship to other disciplines, the quality of life, and societal matters.

The findings of this study strongly emphasize the need for a broad knowledge of technological concepts, communication skills, problem-solving skills, and the relationship of technological principles to related fields in order to be technologically literate. According to Maley (1985), Wright (1984) and Waetjen (1985) the curriculum must provide a basic understanding of the concepts of technology and its relationship to science, math, economics, materials, processes, and social interrelationships. Therefore, those involved with teaching technology need to have a knowledge of the many concepts, applications, and relationships of technology. Technology is ever-changing, and with this change the need for continuing education was identified as an essential component of technological literacy.

5. It may be further concluded, in relation to the previous explanation, that one instruction area alone cannot be responsible for teaching all of the information required to be technologically literate; there must be a combined effort of all areas of instructon.

The literature indicated that it is generally accepted that the area of Technology Education, when properly administered as a general education course, is best suited to deliver the concepts of technological literacy. However, the findings of this study seem to indicate the study of technological literacy and the broad range of criteria identified should be presented through a combined effort of the instructional areas of communications, science, social studies, fine arts, mathematics, and technology. The area of Technology Education is suited to teach hands-on, experiential involvement and allow students to apply the concepts and processes to the tools, machines and equipment. The essential criteria that define technological literacy are included within each of the instruction areas.

6. Based upon the consensus of the panel of experts and the 15 criteria they identified, the following definition of technological literacy was postulated:

> Technological literacy is the ability to understand the meanings and interrlationships of tools, materials, and processes and their varied impacts upon terminology, communication, problem-solving, consumerism, environmental effects, society, personal values and creativity.

This definition implies that the technologically literate person would have knowledge about and understanding of the essential criteria stated in the definition. The analysis of the definition suggests that the technologically literate person would have knowledge of any number of activities ranging from creativity, communication and problem-solving skills, and tools, materials and processes to the impact of various technological concepts and changes on society, environment, consumer economics, and human values and ethics. Those involved with program revision for the purpose of attaining technological literacy should include the essential components implied in the definition and identified in this study.

Recommendations

Based upon the findings of this study, the following recommendations are made:

1. As revealed in the findings, the panelists had a consensus of agreement upon the essential criteria for technological literacy. Since the panelists were representative of a national survey, it is recommended that the criteria identified in this study be tested at the regional or state level for program revision purposes.

2. The priority ranking of the criteria identified in this study

served as the elements for a definition of technological literacy. It is recommended that the postulated definition be tested through further investigation to determine its validity.

3. The various national reports that addressed educational reform placed strong emphasis on the study of technology in America's public schools. Therefore, it is recommended that the programs in higher education include courses to prepare future teachers in the competencies of technological literacy and provide courses and workshops to update those now teaching.

4. It is recommended that the results of this study provide the foundation for the development of a technological literacy test to evaluate the level of technological understanding of individuals. To determine the specific content for the test, it is suggested that each criterion be analyzed individually.

5. Further study should be conducted to determine the relationship between science and physical principles and technology and further the work of DeVore (1987) and others to clarify the confusion between science and technology.

BIBLIOGRAPHY

Andrews, Ted F. "Science Education for the Nonscientist." Educational Technology, Vol. X, No. 1 (January 1970), pp. 29-32.

Arnove, Robert F. and Harvey J. Graff. "National Literacy Campaigns: Historical and Comparative Lessons." Phi Delta Kappan, 69, No. 3 (November 1987), p. 206.

Balistreri, Jerry P. "Technological Literacy - Organizers For Curriculum Design." (Paper presented at the 50th Annual International Technology Education Association Conference, Norfolk, VA, March, 1988).

Barnes, James L. "An International Study of Curricular Organizers for the Study of Technology." Blacksburg, VA: International Institute for the Study of Technology, Inc., 1987.

Benderson, A. "Computer Literacy." Focus, (Educational Testing Service), Vol. 19 (November, 1983), pp. 1-32.

Berger, Raymond M. "What is a Homosexual: A definition model." Social Work, Vol. 28, No. 2 (March-April, 1983), pp. 132-135.

Blankenbaker, E. Keith, and Aaron J. Miller (Ed.). "Technological Literacy: The Roles of Practical Arts and Vocational Education." (Proceedings from an International Symposium on Technological Literacy, Columbus, OH, May, 1987).

Bloom, B. S. (Ed.). Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook 1: Cognitive Domain. New York, NY: David McKay, 1956.

Bloom, L. G. "A Delphi Study to Determine Methods To Aid the Terminally Ill Patient and Their Families." (Unpub. Ed. D. thesis, Oklahoma State University, July, 1979.)

Boyer, Ernest L. High School: A Report on Secondary Education in America. (Carnagie Foundation for the Advancement of Teaching) New York, NY: Harper and Row, Publishers, 1983.

Brockhaus, W. L. and J. F. Mickelson. "An Analysis of Prior Delphi Application and Some Observations on Its Future Applications." Technological Forecasting and Social Changes, No. 10 (1977), pp. 103-110.

Brooks, K. W. "Delphi Technique: Expanding Applications," North Central Association Quarterly, Vol. 53 (1979), pp. 377-385.

Campbell, N. Jo and Katie Perry. (Unpublished paper presented at Designing Questionnaires Workshop, October, 1987.) Stillwater, OK: Oklahoma State University, 1987.

Copa, G. H. "What Should We Do About Research in Vocational Education." Beacon, Vol. 10 (Winter 1981), pp. 1-8.

Cutcliffe, Stephen H. "Technological Literacy for the Nontechnologist." In Proceedings of the Technology Education Symposium II. Monomonie, WI: University of Wisconsin - Stout, May, 1981.

Cyphert, Fredrick R. and Walter L. Gant. "The Delphi Technique: A Case Study." Phi Delta Kappan, Vol. LII, No.5 (January, 1971), pp.272-273.

Dalkey, N. C. and O. Helmer. "An Experimental Application of the Delphi Method to the Use of Experts." Management Science, Vol. 9, No. 3 (April, 1963), pp. 458-467.

Dean, Robert L. "A Delphi Study to Identify Readiness Criteria for the Instructional Design of Classroom Experiential Learning." (Unpub. Ed.D. dissertation Oklahoma State University, July, 1986).

Delbecq, A. L., A. H. Van deVen, and D. H. Gustafson. Group Techniques for Program Planning: A Guide to Nominal Group and Delphi Processes. Glenview, IL: Scott, Foresman, 1975.

DeVore, Paul W. "Science and Technology: An Analysis of Meaning." The Journal of Epsilon Pi Tau, No. 3, (March, 1987), p. 2.

DeVore, Paul W. Technology: An Introduction. Worchester, MA: Davis, 1980.

Dyrenfurth, M. J. Literacy for A Technological World. (Information Series No. 266). Columbus, OH: The National Center for Research in Vocational Education, The Ohio State University, 1984.

Dyrenfurth, Michael J. "Technological Literacy: More than Computer Literacy!" Dallas, TX: National School Boards Association Conference, 1987.

Dyrenfurth, M. J. "The Route to Technological Literacy." Voc. Ed., Vol. 58 (1983), pp. 42-44.

Erekson, Thomas L. "2030 A.D.: The Role of the Technology Teacher Educator." In Proceedings of the Technology Education Symposium IX Denton, TX: North Texas State University, October, 1987.

Folks, John, M. "Our Children's Future: Programs for Progress." Oklahoma City, OK: Oklahoma State Department of Education, December, 1987.

Foster, Phillip R., and Michael R Kozak. "Characteristics of a Model Industrial Technology Education Field Experience." The Technology Teacher, Vol. 8 (November, 1986), pp. 23-26.

Foy, Ron. "2030 A.D.: Interrelationship of Technology Education and the Sciences." (Paper presented at Technology Education Symposium IX, Dallas, TX, October, 1987.)

Fray, Robert B. A Brief Guide to Questionnaire Development. Blacksburg, VA: Learning Resources Center, Virginia Polytechnic Institute and State University, 1983.

Harris, L. Survival Literacy Study. New York, NY: Louis Harris and Associates, 1970.

Harritt, Garey Gene. "Perceptions of Vocational Agriculture Teachers and County Extension Agents as to the Importance and Feasibility of Alternative Approaches to Farming in Southeast Oklahoma." (Unpub. Ed.D dissertation Oklahoma State University, May, 1987.)

Helmer, Olaf. Analysis of the Future: The Delphi Method. Santa Monica, CA: Rand Corporation, 1967.

Hersh, Richard H. "How to Avoid Becoming a Nation of Technopeasants." Phi Delta Kappan Vol. 64, No. 9 (May, 1983), pp. 635-638.

Hopkins, Charles O., Kenneth L. Ritter, and W. L. Stevenson. Delphi: A Planning Tool. Stillwater, OK: Division of Research, Planning and Evaluation, Oklahoma State Department of Vocational and Technical Education, January, 1972.

Hughes, B. B. World Futures: A Critical Analysis of Alternatives. Baltimore, MD: John Hopkins University Press, 1985.

Hurd, Paul. Report of the Second Working Committee on Conceptual Schemes. Washington, DC: National Science Teachers Association, 1968.

Jones, Ronald, Donald Lauda, and John Wright. Work and Education in the Eighties: Monograph 9. Reston, VA: American Council on Industrial Arts Teacher Education, American Industrial Arts Association, 1982.

Judd, R. C. "Use of Delphi Methods in Higher Education." Technological Forecasting and Social Change, No. 4 (1972), pp. 173-186.

Kerlinger, F. N. Foundations of Behavioral Research. New York, NY: Holt, Rindhart, and Winston, Inc., 1973.

Key, James P. Personal Interview. Stillwater, OK, January, 1988.

Key, James P. Research Design. Stillwater, OK: Oklahoma State University, 1974.

Kozol, Johnathan. Illiterate America. Garden City, NY: Anchor Press/ Doubleday, Doubleday, 1985.

Kranzberg, Melvin. "Where Were We Going? Where Have We Gone?" Statement Delivered at the Museum of Science and Industry's Fiftieth Anniversary Conference. Chicago, Illinois, 1983.

La, Porte, J. E. "Challenges in the New Name." Journal of Industrial Teacher Education, Vol. 23, No. 2, (1986), p. 71.

Levin, Henry M. and Russell W. Rumberger. "The Implications of High Technology." Project Report No. 83A4. Washington, DC: National Institute of Education, 1983.

Ley, Connie J. "Technological Literacy and Investigative Imperatives for Vocational Education Researchers." Journal of Vocational Education Research (Winter, 1987), p. 2.

Linstone, H. A. and M. Turoff. The Delphi Method: Techniques and Applications. Reading, MA: Addison-Wesley. 1975.

Loepp, F. "Technological Literacy: An Educational Challenge." Normal, IL: Illinois State University Distinguished Professor Lecture April, 1986.

Lux, Donald G. "Youth's Need for Technological Literacy." Milwaukee, WI: University of Wisconsin, American Industrial Arts Association Annual Conference, April 23, 1983.

MacMillan, D. L. Mental Retardation in School and Society (2nd. ed.). Boston, MA: Little, Brown, 1982.

Maley, Donald. "Issues and Trends in Technology Education." California, PA: California University of Pennsylvania, Technology Education Symposium VII, October, 1985.

Maley, Donald. "Teaching the Heritage of Technology Past, Present, and Future." (Unpub. Report, College Park, MD: University of Maryland, ND, pp. 1-2.)

National Commission on Excellence in Education. A Nation at Risk: Imperatives for Education Reform. Washington, DC: U.S. Department of Education, 1983.

National Science Board Commission on Precollege Education in Mathematics, Science, and Technology. Educating Americans for the 21st Century. Washington, DC: The National Science Foundation, 1983.

Peters, Roy Jr. "A Case Study of Three States Identified as Having a High Quality State Vocational Education System." (Unpub. Doctoral dissertation, Oklahoma State University, 1987.)

Peters, Roy Jr. "The Status of Vocational Education in the State of Oklahoma." (Paper presented at to Oklahoma Vocational-Technical Education Teacher Education Faculty Development Program. Oklahoma State University, April 8, 1988.)

Robb, Janet L. and Michael R. Kozak (Ed.). "Contexts, Elements, Levels: 50 Years Later, 2030 A.D." Technology Education Symposium IX Proceedings. Denton, TX: North Texas State University, October 1987.

Salancik, J. R., W. Wenger, and E. Helfer. "The Construction of Delphi Event Statements." Technological Forecasting and Social Changes, No. 3 (1971), pp. 65-73.

Siegel, S. Nonparametric Statistics. New York, NY: McGraw-Hill, 1956.

Smalley, Lee A. Personal Interview. Dallas, Texas, October, 1987.

Smalley, Lee A. "Technology - A Start." (Unpublished paper, Menomonie, WI: University of Wisconsin - Stout, ND, pp. 20-23.)

Smalley, Lee and Steve Brady. "Technology Literacy Test." (Unpublished research report to the American Council on Industrial Arts Teacher Education. Menomonie, WI: University of Wisconsin - Stout, 1984.)

Snyder, J. F. and J. A Hales. Jackson's Mill Industrial Arts Curriculum Theory. Charleston, WV: Department of Education, 1981.

Task Force on Education for Economic Growth. Action for Excellence: A Comprehensive Plan to Improve Our Nation's Schools. Washington, DC: Education Commission of the States, 1983.

Technology Education Act of 1985, H.R. 3102. Washington, DC: The House of Representatives, U. S. Congress, 1985.

Teske, Stephen. "Reading Ability No Longer Sole Determinant of Literacy, Experts Say." Report on Education Research. Alexandria, VA: Capitol Publication, In., Vol. 19, No. 24 (December 2, 1987), p. 7.

Waetjen, W. B. People and Culture in our Technological Society in Technology Education: Perspective on Implementation. Reston, VA: International Technology Education Association, 1985.

Warner, W. A. "A Curriculum to Reflect Technology." (Introduced at the American Industrial Arts Association Conference in 1947.) Columbus, OH: Epsilon Pi Tau, 1965.

Washburn, Sherwood L. "Tools and Human Evolution." In M. F. Ashley Montague (Ed.) Culture and the Evolution of Man. New York, NY: Oxford University Press, 1962, p. 13.

Webster's New World Dictionary. David B. Guralnik (Ed.). New York, NY: Warner Books, Inc., 1984.

Wicklein, Robert C. Personal Interview. Stillwater, Oklahoma, November, 1987.

Wright, R. Thomas. "A Guide for Organizing Content for Technology Education." International Symposium on Technological Literacy Proceedings. Columbus, OH: The Ohio State University, 1987.

APPENDIXES

APPENDIX A

STATES REPRESENTED IN THE STUDY

States Represented in Study	
California	Nevada
Colorado	North Carolina
Florida	Ohio
Georgia	Oklahoma
Indiana	Texas
Kansas	Virginia
Maryland	Washington, D. C.
Minnesota	Wisconsin
Missouri	

APPENDIX B

REQUEST TO PARTICIPATE AND RESPONSE CARD

Oklahoma State University

SCHOOL OF OCCUPATIONAL AND ADULT EDUCATION

STILLWATER, OKLAHOMA 74078
CLASSROOM BUILDING 406
(405) 624-6275

February 17, 1988

Dear

The Industrial Technology Education program area of the School of Occupational and Adult Education here at OSU has been revised from a traditional Industrial Arts program to the Technology Education concept. Based upon current trends in education, the problem of technological literacy has become an important topic.

One of the critical issues remaining is to identify the criteria that a technological literate person should possess, and establish a definition of technological literacy based upon these criteria. This study has the support of the Oklahoma State Department of Vocational and Technical Education and will be of extreme value to Technology Education departments as they develop and improve course content.

Because of your expertise in vocational education, I request your participation in my study. I will be conducting a three, and possibly four, probe Delphi involving professional educators, administrators, and representatives from business and industry to identify the technological literacy criteria. Each probe will require about 15 minutes of your time.

Please return the enclosed post card indicating your willingness to participate in this study. The Delphi process preserves anonymity; therefore, names will not be used in tabulations. If you are able to participate, the first forms will be sent to you without delay. I expect all of the probes to be completed by May 1, 1988.

Sincerely yours,

Dennis R. Baker

Dennis R. Baker
Instructor, Industrial Technology Education

DRB:mkr

Enclosure

_____ Yes, I will be able to participate in your study.

_____ No, I will not be able to participate in your study.

Signed_______________________________

Dennis R. Baker
Oklahoma State University
School of Occupational & Adult Education
406 Classroom Building
Stillwater, Oklahoma 74078-0406

APPENDIX C

DELPHI I COVER LETTER AND INSTRUMENT

OSU

Oklahoma State University

SCHOOL OF OCCUPATIONAL AND ADULT EDUCATION
COLLEGE OF EDUCATION

STILLWATER, OKLAHOMA 74078-0406
CLASSROOM BUILDING 406
(405) 624-6275

March 9, 1988

Dear

Thank you for agreeing to participate in my study of technological literacy. You are among twenty-seven experts in the areas of business and industry, administration, and professional education from across the nation who will be providing valuable information for researching the concept of technological literacy, to bring our profession one step closer to an accepted definition. Your opinions and ideas are extremely important.

Specifically, I ask you to identify the criteria, or educational concepts, that characterize a technologically literate person.

I am attaching the first of three probes to identify the criteria. Feel free to include as many responses as you feel necessary, and return the instrument in the enclosed self addressed stamped envelope by March 18, 1988, if at all possible.

As soon as the results of this first round have been tabulated, you will receive the analysis and have the opportunity to express your opinion once again for further clarification of the criteria.

Thank you again for your valuable time. As I noted in my first letter, the Delphi process preserves anonymity; therefore names will not be used in tabulations.

Sincerely,

Dennis R. Baker

Dennis R. Baker

DRB:mkr

Enclosures

DELPHI I

Name ____

(Your name is needed so I may return your responses to show how you compare with the rest of the group as we proceed with Round II.)

Technological literacy has become a major objective of Technology Education. Even though there has been considerable attention given to the concept of technological literacy and its meaning, there still remains an element of question. Your expert opinion will help identify the criteria that a technologically literate person should possess.

Directions: Please answer the following question with brief and concise statements, or you may choose to list your answers. Feel free to use additional pages and include as many responses as you feel necessary.

In your response please consider that criteria are standards or educational outcomes.

WHAT DO YOU FEEL ARE THE CRITERIA, OR EDUCATIONAL CONCEPTS

THAT CHARACTERIZE A TECHNOLOGICALLY LITERATE PERSON?

Example: A technologically literate person should be able to solve problems.

APPENDIX D

DELPHI II COVER LETTER AND INSTRUMENT

Oklahoma State University

SCHOOL OF OCCUPATIONAL AND ADULT EDUCATION

STILLWATER, OKLAHOMA 74074
CLASSROOM BUILDING 406
(405) 624-6276

Thank you once again for your participation in my study of technological literacy. The response has been exceptional, and I certainly appreciate your information and ideas.

I received 146 statements concerning the question, "What do you feel are the criteria, or educational concepts, that characterize a technologically literate person?" Through a computer analysis and a systematic process involving a group decision, the 146 statements were grouped into 25 categories of like responses. These 25 criteria make up this second Delphi probe.

To further refine the criteria that a technologically literate person should possess, I am asking you to please complete the enclosed probe. Specifically, I ask that you: (1) indicate the 15 most important criteria by placing a checkmark in the first blank, (2) rank the 15 you have selected using numerals 1 through 15 in the second blank with one [1] as the most important, and (3) feel free to add new criteria or make comments.

I ask that you return the instrument by April 11 so it can be analyzed. Again, thank you for your support.

Sincerely,

Dennis R. Baker

Dennis R. Baker

DRB:mkr

Enclosure

CENTENNIAL
1890 • 1990

Celebrating the Past . . . Preparing for the Future

DELPHI II

NAME:____________________________________

INSTRUCTIONS: Please review each of the 25 criteria identified in Questionnaire No. 1. Each is a criterion that characterizes a technologically literate person. The statements have been randomly placed for you to:

1. Indicate the 15 most important criteria by placing a check mark in the first blank.
2. Rank the 15 you have selected using numerals 1-15 in the second blank, with (1) as the most important.
3. Feel free to add new criteria or make comments.

Best Items	Rank of selected Items	Criteria that characterize a technologically literate person
___	___	1. Understands the impact of global competition.
___	___	2. A knowledge of one's personal limits when dealing with technology.
___	___	3. Understanding of engineering design.
___	___	4. Understand and apply decision-making and cost justification processes.
___	___	5. Able to identify a technological problem, gather information for solving the problem, analyze the system (synthesis) to find a solution, and understand the scientific approach to evidence.
___	___	6. Knows that continuing education is important.
___	___	7. Able to understand and adapt to change brought about by technology with an open mind.
___	___	8. One who has achieved culture. (Greek: paideia)
___	___	9. The ability to evaluate a technological process or product in terms of the personal, economic, and societal benefits of its applications.
___	___	10. Understanding of the specific technological terminology....and the ability to read, interpret, and communicate the terminology to all levels- from workers to managers.
___	___	11. An awareness of key technical processes and the principles behind them. (eg. how things work)
___	___	12. Knowledge of technological information resources and locations so one can access technical information.

____ ____ 13. Understands and proficient in the application of scientific principles upon which technology is based.

____ ____ 14. Recognize the contributions that innovative thinking, abstract thinking, and critical thinking produces for technology.

____ ____ 15. Awareness of key existing and emerging technological processes and their impact on the workplace and society.

____ ____ 16. Ability to use technological artifacts (tools, machines, materials, and processes) commensurate with one's social and occupational role in life.

____ ____ 17. Understand and have the ability to develop creative skills, and be open to "doing things differently."

____ ____ 18. Understands and participates in the democratic process involving issues that pertain to science and technology, public policy, and legislation.

____ ____ 19. Awareness of evolving technologies, and be able to predict possible impacts upon environment, society, human concerns, and individuals.

____ ____ 20. Understanding related to the benefits and risks of choosing technologies.

____ ____ 21. Must have character to accept counsel or criticism, ambition and desire to accomplish, and be able to develop self-confidence and not be discouraged by failure.

____ ____ 22. Insight as to the relationship between careers and the technological future.

____ ____ 23. Connect past technological events to the present, and be able to project alternative futures.

____ ____ 24. Understand the interactions and effects of science and technology on society, and human values of ethics and morality.

____ ____ 25. Ability to conceptualize how an unfamiliar technological process or machine operates.

Additions or Comments:

APPENDIX E

DELPHI III COVER LETTER AND INSTRUMENT

Oklahoma State University

SCHOOL OF OCCUPATIONAL AND ADULT EDUCATION

STILLWATER, OKLAHOMA 74074
CLASSROOM BUILDING 406
(405) 624-6276

April 25, 1988

Dear

Your responses to the second Delphi probe, which asked you to rank the 15 most essential criteria that characterize a technologically literate person, have been tabulated. The Delphi Technique has been used extensively in Educational Research, and one of the reasons for its success is the willingness of people like you to participate. The response for this study has been exceptional, and I thank you for your input.

In this third and final probe, please examine the 15 criteria that the panel has identified. Each criterion has been listed in the rank order of the responses to Delphi II, along with the number of ranking points received. A point system (15 points for a ranking of "1", 14 points for a ranking of "2", etc.) was used to calculate the rankings. You might notice that there was a tie for tenth place, in which the criterion that received the most votes from the panel was ranked higher.

To complete the probe, please compare the criteria with your Delphi II response and determine if you still agree, or if you wish to make a change. Rank the 15 criteria from one to 15 by assigning "1" the most essential, "2" second, etc. Space has been provided for you to justify your choices and and make comments about the criterion selection.

If possible, please return the instrument by Friday, May 6, 1988, so final analysis may begin.

In the near future, you will receive a copy of a summary report of the study, with a listing of all criteria in the order of their importance, and the study conclusions.

Again, I want to thank you very much for your support.

Sincerely,

Dennis R. Baker

Dennis R. Baker

DRB:mkr

Enclosure

DELPHI III

NAME: ______________________________

INSTRUCTIONS: These 15 criteria that characterize a technologically literate person appear in the order of ranking as a result of your response to Delphi II. The number of points accumulated in that ranking appear beside each criterion, along with the rank you assigned in Delphi II. You are asked to determine if you still agree with your choice, or do you wish to make a change. Please justify your choices and rank these 15 criteria by placing a "1" in the blank in front of the criterion you feel is most essential, "2" second, etc.

YOUR FINAL VOTE	DELPHI II RESULTS	YOUR II RANK	CRITERIA (in order of rank)	COMMENTS
____	225	____	1. Understanding of the specific technological terminology....and the ability to read, interpret, and communicate the terminology to all levels--from workers to managers.	
____	215	____	2. Able to identify a technological problem, gather information for solving the problem, analyze the system (synthesis) to find a solution, and understand the scientific approach to evidence.	
____	204	____	3. An awareness of key technical processes and the principles behind them. (eg. how things work)	
____	181	____	4. Knowledge of technological resources and locations so one can access technical information.	
____	168	____	5. Able to understand and adapt to change brought about by technology with an open mind.	
____	137	____	6. Awareness of evolving technologies, and be able to predict possible impacts upon environment, society, human concerns, and individuals.	
____	134	____	7. Understand the interactions and effects of science and technology on society, and the human values of ethics and morality.	
____	132	____	8. Ability to use technological artifacts (tools, machines, materials, and processes) commensurate with one's social and occupational role in life.	
____	131	____	9. The ability to evaluate a technological process or product in terms of the personal, economic, and societal benefits of its applications.	
____	124	____	10. Awareness of key existing and emerging technological processes and their impact on the workplace and society.	
____	124	____	11. Knows that continuing education is important.	
____	121	____	12. Understands and is proficient in the application of scientific principles upon which technology is based.	
____	120	____	13. Understands and has the ability to develop creative skills, and be open to "doing things differently."	
____	119	____	14. Recognize the contributions that innovative thinking, abstract thinking, and critical thinking produces for technology.	
____	97	____	15. Connect past technological events to the present and be able to project alternative futures.	

APPENDIX F

CRITERIA IDENTIFIED IN DELPHI I

Has an understanding of the interactions and effects of science and technology on society, and human values of ethics and morality.

Ability to conceptualize how an unfamiliar technological process or machine operates.

Connect past technological events to the present and be able to project alternative futures.

Understanding of past events that have positively or negatively affected world wide product and manufacturing technology. eg. Robotics, just in time-manufacturing, labor unions, computer design.

Develop a broad perspective on the role that technology has played in the evolving civilizations past and present.

Understands how tools, processes, and systems have been used to aid human survival. (5 duplicate)

Ability to project alternative futures based on technological capacities and applications. (2 duplicate)

Develop a process of technology assessment for influencing the choice of future technologies.

Insight as to the relationship between careers and the technological future.

Understand the implications of career choices in the field of technology.

Must have the character to accept counsel or criticism.

Must be able to develop self-confidence and not be discouraged by failure.

Ambition and want to accomplish.

Understanding related to the benefits and risks of choosing technologies.

Demonstrate awareness of evolving technologies, and be able to predict possible impacts upon various aspects of society.

The ability to appraise the adaptability of new technology in one's environment.

Knowledge of and concern for choice and use of technology and its influence on environment, through personal life-style.

Apply technological knowledge to a variety of human concerns and situations.

Familiarity with technology's effects on individuals and society.

Understanding that science and technology are not the sole blame for societal problems, eg. pollution, resource depletion.

A knowledge of one's personal limits when dealing with technology. (eg. When to call an expert to fix something rather then screwing it up yourself.)

A sense of personal limits. (eg. When to call on expert.)

Understands the impact of global competition.

Understanding that technology has created interdependences on a global scale.

Thorough understanding of world wide competition and technological capabilities.

Understand and be able to apply decision-making and cost justification processes.

Be a wise consumer/decision maker concerning technological products/services.

Understanding of the relationships as well as impacts of technological decisions and human values.

Make effective decisions about the purchase and appropriate use of tools, machines, processes, materials, and software from an economic perspective, (personal, local, national, international).

Able to identify a technological problem. Able to gather information for solving the problem. Systematically analyze the system (synthesis) to find a solution.

Comprehend and utilize scientific principles needed in enhancing the solution of technological problems.

Be able to solve technological problems. (6 duplicate)

Inclination and imagination to apply existing technology to new problems or situations.

Able to place technological problems, events, etc. in the appropriate social context and use this in their analysis. (2 duplicate)

Understand and use the basic/applied math and physics concepts to the areas of manufacturing, construction, transportation, and communications.

Apply concept of science and mathematics toward problem solving and task achievement.

To collect, organize, and analyze data, using appropriate tools such as sensors, computers, etc.

Understanding of the scientific approach to evidence and theory building. (4 duplicate)

Be able to solve simple to broad problems in the relationships within and between the worlds of manufacturing, transportation, construction, and computer and electronic systems.

Understanding of engineering design.

Knows that continuing education is important; the jobs of the future will constantly change.

Be willing to devote on-going reading and study to new and upcoming technological advancements.

Able to understand and adapt to change brought about by technology.

Understanding of the changes occurring in current technologies.

An awareness of changes taking place in the present society because of technological innovations.

Maintain a positive attitude toward changes in technology, without blind acceptance, while properly and thoroughly evaluating the benefits of its applications.

The ability to understand, accept, adapt to or apply new technology and the changes it brings to one's business or personal life.

Demonstrate receptiveness to new ideas and new data even though it may not necessarily fit with what has previously been learned.

Common sense in approaching a task or project.

Open-mindedness to learn.

Must be teachable.

Willingness to examine technological alternatives in daily life.

One who has achieved culture or as Greeks indicated paideia.

The ability to evaluate a technological process or product in terms of the personal benefits to you the consumer.

Understanding of exclusivity and its impact on market acceptance or manufacturing competitiveness.

Should be able to relate the relationship of economics to manufacturing, construction, transportation, and communications.

Predisposition to evaluate a technological process or product in terms of personal benefit as a consumer.

Ability to evaluate a technological process or product in terms of personal benefit as a consumer.

Able to evaluate technologies as to their appropriateness in our world.

Able to assess the value of finished goods on economic, personal, and societal terms.

Thorough understanding of the specific technological terminology. . . and the ability to read, interpret, and communicate the terminology.

Has the ability to read, comprehend, and communicate about science, and technology issues.

Competent in math and communication skills. (2 duplicate)

Communication skills in dealing with people of all levels of workers, from managers to owners. (2 duplicate)

Must be able to communicate well in written and spoken language. (5 duplicate)

To communicate technical information to non-technically oriented persons, using print, speech, demonstration, or other means of transmission of knowledge. (2 duplicate)

Understand and speak with confidence and use the vocabulary in the computer field.

Able to read maps, charts, graphs, drawings, instructions, etc.

Be able to communicate technical concepts in less technical terms to that level of management where business decisions are to be made.

Must be able to communicate ideas to peers who are literate in the same technology.

Able to present data which explains technological phenomena.

Understand reading materials in technological areas written at the 10th grade level.

An awareness of key technical processes and the principles behind them. (eg. How things work.) (3 duplicate)

Comfortable in employing a wide range of technologies in their daily life.

A knowledge of technological information resources and locations so one can access technical information when needed.

Identify resources (human, information, materials, tools) involved in a technological society in a general manner, but able to work with these in specifics when encountering a specific technological problem.

Knowledge of technological information sources and assessing and storage methods.

Must recognize the contributions that innovative thinking produces.

Is a critical thinker and has a questioning nature.

Must be skilled in numbers sense and abstract thinking.

Understands the scientific principles upon which technology is based.

Must be proficient in the application of scientific principles.

Ability to employ technological information processing methods.

Awareness of key technological processes and their governing principles.

To demonstrate awareness of existing technologies and an understanding of the impact those technologies have on various aspects of society.

Understands the impact of technology in the workplace - now and in the future.

Understanding and appreciation for the role and function of technology in society.

Understanding of essential relationships among key principles and areas of technology.

Knowledge of existing and emerging technologies. (2 duplicate)

Understand and have the ability to develop creative skills.

Creative and open to doing things differently.

Technological competitiveness is dependent on innovation, which requires creativity.

Develop the sense and thorough understanding for the need to be creative.

Understands and participates in the democratic process to issues involving science and technology.

Be able to make choices about public policy which influence use of technology. (eg. define policy for elimination of acid rain, rebuilding ozone layer, etc.)

Ability to use technological artifacts (tools, machines, materials, and processes) commensurate with one's social and occupational role in life.

The ability to use the technological artifacts necessary for everyday living. (eg. tools, machines, materials and processes) (3 duplicate)

Ability to use technological artifacts (tools, machines, materials and processes) commensurate with one's stage of physical development.

Be proficient in the use of computers including simple basic programming languages, as well as the repair and maintenance of machinery.

Has some mechanical aptitude.

Use tools, machines, processes, and materials in order to effectively and efficiently accomplish work. (4 duplicate)

Comfort with basic technological hardware. (willingness to use tools, machines and materials)

Able to identify effective and efficient new uses for tools, materials, machines, and processes in order to accomplish work.

Effectively and efficiently learn to use new tools, machines, materials, processes, and software as they become available.

VITA

Dennis R. Baker

Candidate for the Degree of

Doctor of Education

Thesis: TECHNOLOGICAL LITERACY: THE ESSENTIAL CRITERIA FOR A DEFINITION

Major Field: Occupational and Adult Education

Biographical:

Personal Data: Born in Caldwell, Kansas, March 25, 1943, the son of Kenneth R. and Alice Baker; married to Kathleen Troyer, August 22, 1964.

Education: Graduated from Bluff City High School, Bluff City, Kansas, May 16, 1961; Received Bachelor of Science in Education degree with a major in Biological Science and minors in Physical Science and Industrial Education from Kansas State Teachers College Emporia, Kansas, August, 1965; Received Master of Science in Education degree with a major in Industrial Education from Pittsburg State College, Pittsburg, Kansas, May, 1966; completed requirements for Doctor of Education degree at Oklahoma State University in July, 1988.

Professional Experience: Instructor, Wichita Public Schools, Wichita, Kansas, 1966-72; Instructor, Chaparral High School, Anthony, Kansas, 1972-75; Owner, Baker Construction Company, 1975-88; Owner-Operator, Baker Farms, Anthony, Kansas, 1974-present; President Kansas State University Agricultural Council, 1985-87; Chairman, Kansas State University Extension Advisory Board 1985-86; Graduate Assistant, Industrial-Technology, Oklahoma State University, 1986-87; Instructor, Industrial-Technology Education, Oklahoma State University, 1987-88.

Professional Organizations: International Technology Education Association, American Vocational Association, Oklahoma Vocational Association, Phi Delta Kappa, Iota Lambda Sigma, American Vocational Research Association, Council of Technology Educators.