FOUNDATIONS OF TECHNOLOGY EDUCATION

1995

44th Yearbook

Council on Technology Teacher Education

FOUNDATIONS OF TECHNOLOGY EDUCATION

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FOREWORD

The Council on Technology Teacher Education is once again blessed with an outstanding yearbook. This year's editor, Dr. G. Eugene Martin, previously edited the 28th yearbook, entitled *Industrial Arts Education: Retrospect, Prospect* (1979). That yearbook provided the profession with a comprehensive look at industrial arts education from the perspectives of the past, present, and future. It proved to be one of the Council's finest yearbooks.

Dr. Martin has once again taken a comprehensive examination of our field, but in this case it is technology education. This yearbook emphasizes the constructs that have transitioned technology education into the present and, we hope, on into the future.

At the time the yearbook proposal was submitted to the Yearbook Planning Committee for their review, the editor made it clear that the yearbook would accomplish the following: (a) not be a repeat of the *Retrospect, Prospect* yearbook, (b) focus on the now and the future of technology education, (c) seldom make reference to industrial arts, (d) focus on interests of undergraduate level college students, and (e) stimulate thought and cause readers to ask questions. The table of contents documents that Dr. Martin has excelled in achieving his goals. He has selected outstanding authors who have written exceptional chapters. The yearbook has been organized so that the reader develops a perspective of technology education and how it differs from other technical academic programs. Technology education and its relationship to the liberal arts, humanities, science, and mathematics is one of the focal points. Major technology education curriculum projects are summarized, instructional facilities identified, and the process and support systems for implementing technology education are presented. Other topics addressed are instructional strategies, undergraduate and graduate technology education, leadership, the International Technology Education Association, related professional councils and associations, and technology education as a global influence.

The Council is honored to have the opportunity to present this yearbook to the profession. We sincerely thank Dr. Martin and each of the authors for all their contributions to its development.

Everett N. Israel
President, CTTE

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YEARBOOK PROPOSALS

Each year, at the ITEA International Conference, the CTTE Yearbook Committee reviews the progress of yearbooks in preparation and evaluates proposals for additional yearbooks. Any member is welcome to submit a yearbook proposal. It should be written in sufficient detail for the committee to be able to understand the proposed substance and format. Fifteen copies of the proposal should be sent to the committee chairperson by February 1 of the year in which the conference is held. Below are the criteria employed by the committee in making yearbook selections.

CTTE Yearbook Committee

CTTE Yearbook Guidelines

A. Purpose:

The CTTE Yearbook Series is intended as a vehicle for communicating education subject matter in a structured, formal series that does not duplicate commercial textbook publishing activities.

B. Yearbook topic selection criteria:

An appropriate yearbook topic should:

1. Make a direct contribution to the understanding and improvement of technology teacher education.
2. Add to the accumulated body of knowledge of the field.
3. Not duplicate publishing activities of commercial publishers or other professional groups.
4. Provide a balanced view of the theme and not promote a single individual's or institution's philosophy or practices.
5. Actively seek to upgrade and modernize professional practice in technology teacher education.
6. Lend itself to team authorship as opposed to single authorship.

Proper yearbook themes *may* also be structured to:

1. Discuss and critique points of view which have gained a degree of acceptance by the profession.
2. Raise controversial questions in an effort to obtain a national hearing.
3. Consider and evaluate a variety of seemingly conflicting trends and statements emanating from several sources.

C. The yearbook proposal:

1. The Yearbook Proposal should provide adequate detail for the Yearbook Planning Committee to evaluate its merits.
2. The Yearbook Proposal should include:
   a. An introduction to the topic
   b. A listing of chapter titles
   c. A brief description of the content or purpose of each chapter
   d. A tentative list of authors for the various chapters
   e. An estimate of the length of each chapter

PREVIOUSLY PUBLISHED YEARBOOKS

*1. *Inventory Analysis of Industrial Arts Teacher Education Facilities, Personnel and Programs,* 1952.
*2. *Who's Who in Industrial Arts Teacher Education*, 1953.
*3. *Some Components of Current Leadership: Techniques of Selection and Guidance of Graduate Students; An Analysis of Textbook Emphases;* 1954, three studies.
*4. *Superior Practices in Industrial Arts Teacher Education,* 1955.
*5. *Problems and Issues in Industrial Arts Teacher Education*, 1956.
*6. *A Sourcebook of Reading in Education for Use in Industrial Arts and Industrial Arts Teacher Education,* 1957.
*7. *The Accreditation of Industrial Arts Teacher Education*, 1958.
*8. *Planning Industrial Arts Facilities,* 1959. Ralph K. Nair, ed.
*9. *Research in Industrial Arts Education*, 1960. Raymond Van Tassel, ed.
*10. *Graduate Study in Industrial Arts,* 1961. R. P. Norman and R. C. Bohn, eds.
*11. *Essentials of Preservice Preparation*, 1962. Donald G. Lux, ed.
*12. *Action and Thought in Industrial Arts Education*, 1963. E. A. T. Svendsen, ed.
*13. *Classroom Research in Industrial Arts*, 1964. Charles B. Porter, ed.
*14. *Approaches and Procedures in Industrial Arts*, 1965. G. S. Wall, ed.
*15. *Status of Research in Industrial Arts*, 1966. John D. Rowlett, ed.
*16. *Evaluation Guidelines for Contemporary Industrial Arts Programs,* 1967. Lloyd P. Nelson and William T. Sargent, eds.
*17. *A Historical Perspective of Industry,* 1968. Joseph F. Luetkemeyer Jr., ed.
*18. *Industrial Technology Education,* 1969. C. Thomas Dean and N. A. Hauer, eds. *Who's Who in Industrial Arts Teacher Education,* 1969. John M. Pollock and Charles A. Bunten, eds.
*19. *Industrial Arts for Disadvantaged Youth,* 1970. Ralph O. Gallington, ed.
*20. *Components of Teacher Education*, 1971. W. E. Ray and J. Streichler, eds.
*21. *Industrial Arts for the Early Adolescent*, 1972. Daniel J. Householder, ed.
*22. *Industrial Arts in Senior High Schools,* 1973. Rutherford E. Lockette, ed.
*23. *Industrial Arts for the Elementary School,* 1974. Robert G. Thrower and Robert D. Weber, eds.
*24. *A Guide to the Planning of Industrial Arts Facilities*, 1975. D. E. Moon, ed.
*25. *Future Alternatives for Industrial Arts,* 1976. Lee H. Smalley, ed.
*26. *Competency-Based Industrial Arts Teacher Education,* 1977. Jack C. Brueckman and Stanley E. Brooks, eds.
*27. *Industrial Arts in the Open Access Curriculum*, 1978. L. D. Anderson, ed.
*28. *Industrial Arts Education: Retrospect, Prospect*, 1979. G. Eugene Martin, ed.
*29. *Technology and Society: Interfaces with Industrial Arts*, 1980. Herbert A. Anderson and M. James Benson, eds.
*30. *An Interpretive History of Industrial Arts,* 1981. Richard Barella and Thomas Wright, eds.
*31. *The Contributions of Industrial Arts to Selected Areas of Education,* 1982. Donald Maley and Kendall N. Starkweather, eds.
*32. *The Dynamics of Creative Leadership for Industrial Arts Education,* 1983. Robert E. Wenig and John I. Mathews, eds.
*33. *Affective Learning in Industrial Arts*, 1984. Gerald L. Jennings, ed.
*34. *Perceptual and Psychomotor Learning in Industrial Arts Education*, 1985. John M. Shemick, ed.
*35. *Implementing Technology Education,* 1986. Ronald E. Jones and John R. Wright, eds.
*36. *Conducting Technical Research*, 1987. Everett N. Israel and R. Thomas Wright, eds.
*37. *Instructional Strategies for Technology Education,* 1988. William H. Kemp and Anthony E. Schwaller, eds.
38. *Technology Student Organizations*, 1989. M. Roger Betts and Arvid W. Van Dyke, eds.
39. *Communication in Technology Education,* 1990. Jane A. Liedtke, ed.
40. *Technological Literacy*, 1991. Michael J. Dyrenfurth and Michael R. Kozak, eds.
41. *Transportation in Technology Education,* 1992. John R. Wright and Stanley Komacek, eds.
42. *Manufacturing in Technology Education,* 1993. Seymour and Shackelford, eds.
43. *Construction in Technology Education*, 1994. Richard M. Henak and Jack W.Wescott, eds.

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*Out-of-print yearbooks can be obtained in microfilm and in Xerox copies. For information on price and delivery, write to Xerox University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan, 48106.

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UNIT III: LEADERSHIP, ORGANIZATIONS, AND PUBLICATIONS IN TECHNOLOGY EDUCATION

PREFACE

This yearbook provides the reader with a foundation for understanding a movement in education that has become known and recognized throughout the world as technology education, while specifically drawing attention to those key constructs that guided the profession through a transition period. Program implementation and integration, facilities, curriculum theory and professional practices, leadership, organizations and associations, and professional publications are indicative of these constructs.

At no time in the history of the profession has the topic of technology education been more hotly and yet richly debated by classroom teachers, supervisors, and teacher educators than during the past 15 years. The transition to technology education has not been easy, as the change has attacked the very comfort level of every person impacted by the movement. Now, more than ever before, as we prepare to enter the 21st century, technology education stands at the threshold of a unique opportunity to make meaningful and significant differences in the lives of every school age person.

The publication of the 44th Yearbook of the Council on Technology Teacher Education represents the culmination of three years of active research and writing by a group of dedicated, committed, and distinguished professionals in technology education. Each has contributed in a special way to the development of a professional publication most worthy of a place in every technology educator's library. I am deeply indebted to these authors, without whom this yearbook simply would not have been possible. They have given time, when their time was not readily available; energy, when their energy was already exhausted; and talent, when their talent was demanded elsewhere. The authors bring to this yearbook unique abilities that are rich in experience in the field of technology education. They have all been active participants in the profession during the transition period and they represent some of its finest minds and thoughts. Their names are those that people in the profession most commonly associate with the term technology education.

The unique contributions of each author will become readily apparent to the reader in each chapter. Not only do the authors cover their topics in a very thorough yet detailed way, they also provide one with much food for thought. I am confident that just a cursory review of the chapters will cause the reader to return and study each of them in much more detail. I would be remiss if I did not call special attention to one of the authors—Douglas L. Polette, who succumbed to an illness as he was preparing his topic. He was fully cognizant of his personal time line throughout the writing process and, like the true professional, completed his chapter shortly before his death.

It is my desire that this yearbook will make a valuable contribution to the technology education profession and especially to the many people who contemplate entering it now and in the future. It is also my desire that through the publication of this yearbook I, as editor, will have been able to give back to the profession, in a symbolic way, a small token of my appreciation for all the opportunities it has afforded me. I submit to you this yearbook for your information and enjoyment.

G. Eugene Martin
Editor

ACKNOWLEDGMENTS

Commitment! That's what it takes to write a yearbook for the Council on Technology Teacher Education (CTTE). Understanding! You will need a lot of it from your peers and family alike. Dedication! Without dedication, a yearbook will never come to fruition. Trust! You must trust your authors because they are the experts. Diligence! Stay with it, persevere, and all your rough drafts will eventually result in final copy. These words are but a few of the descriptors that could be used to explain how the team of this yearbook's authors developed *Foundations of Technology Education.*

Every technology teacher educator should take advantage of the professional opportunity to serve as a yearbook editor. It is a challenging task, but one for which considerable help and support is accessible. The officers and Yearbook Planning Committee of the CTTE have developed and made available to the profession a set of basic guidelines to follow when developing a proposal. Using these guidelines, the 1992 Yearbook Planning Committee members met at the International Technology Education Association (ITEA) conference in Minneapolis, Minnesota, to approve the concept of a yearbook that would cover the foundations of technology education. Their determination to continue the excellence of the yearbook series reinforced my desire to be the editor of a second CTTE yearbook. Their commitment and encouragement did not waver throughout its development.

The profession is deeply indebted to the CTTE for its dedication to scholarship and the pursuit of knowledge through the yearbook series. A special thanks goes to those teacher educators who, in the late 1940s, saw a need for a separate teacher education council and who, at their organizational meeting on May 10, 1950, endorsed the idea for a yearbook series. Although several teacher educators assumed important roles initiating plans for the series, the profession is most grateful to the following people for making it a reality: Walter R. Williams, Jr., John A. Whitesel, DeWitt Hunt, William McKnight, Jr., and Wesley D. Stephens. Past and present CTTE officers, yearbook editors, and chapter authors have made the yearbook series a significant resource for 44 years.

There are many people within the technology education profession who have had a significant influence on my professional life and, no doubt, encouraged me at various stages in my professional development. Joseph F. Luetkemeyer, Professor Emeritus at the University of Maryland, served as my graduate advisor. He assisted me throughout my doctoral studies. John A. Whitesel was one of my colleagues during my tenure at Miami University

(Ohio). John was one of the founding fathers of the CTTE (then ACIATE) and the yearbook series, and served as President of the American Industrial Arts Association (now ITEA). John's knowledge was rich with information on the early stages of development of the profession. Donald Maley, Professor Emeritus at the University of Maryland, provided me with encouragement throughout my professional career. He was always there to share ideas and to criticize my "original" thoughts constructively. The technology education profession is in a better position today because of the lifetime contributions of Donald Maley.

The Southwest Texas State University faculty and administration have been most generous in their encouragement and support at all stages in the preparation of the yearbook. Their emphasis on the scholarly development of faculty helped to reinforce my commitment to this scholarly publication. I thank them immensely for all their support.

I am particularly grateful to Melinda Habingreither, who so graciously assisted me in all phases of the editorial process for this yearbook. Melinda's exceptional editorial talents provided the necessary encouragement to bring a yearbook to fruition. This yearbook could not have been completed without her editorial skills and her commitment to details. Warren Mack, Assistant Professor in the Department of Technology at Southwest Texas State University, provided valuable assistance in the final development of the graphics for this yearbook. His experience in graphic design was immeasurable.

I also want to pay a special tribute to my wife, Glenda, and our son, Christopher. Each provided me with encouragement to take on the demanding task of being a yearbook editor and to complete the task when there were other more important family responsibilities. Their support was just as strong during the development of this yearbook as it was when I served as editor of the 28th ACIATE yearbook. They are, no doubt, an extension of both my personal and professional life and I thank both of them for all of their support.

G. Eugene Martin
Editor

CHAPTER 1

A Context For Technology Education

M. James Bensen (President, Bemidji State University)
Bemidji, Minnesota

Technology is a phenomenon that is unfolding throughout our global society at an unprecedented pace and with incredible ramifications. Everyone uses technology; unfortunately, many abuse it. Many people purchase it; unfortunately, a few steal it. A few people comprehend it; unfortunately, not many fully understand it. Technology can be as simple as that which was developed by the early wood, bone, or stone tool users or as sophisticated as the systems that support the space shuttle. Technology is everywhere and it is an integral part of how and where people live, work, recreate, and socialize. Without technology, humans are extremely limited in what they can accomplish, but with it, humans are able to exert virtually unlimited power and energy in reaching their full potential.

TECHNOLOGY DEFINED

Technology is a term that has outpaced the definitions commonly found in home and library dictionaries. When reviewing standard dictionary definitions of technology, for example, definitions such as "the science or study of the practical or industrial arts" (Webster's, 1959, p. 1001) are found. A more contemporary dictionary entry shows little expansion on the above definition, as it states that technology is the "practice of any or all of the applied sciences that have practical or industrial use" (Webster's, 1990, p. 564). Most leaders in the field of technology (not limited to the leaders in the field of technology education) would readily agree that such definitions are rather limited, too narrow, and out of touch with the contemporary global scene. In a faculty study conducted at the University of Wisconsin-

Stout, over 200 definitions of technology were identified and reviewed (Gebhart, et al., 1979). These definitions ranged from the highly esoteric to that of the more "folksy," yet profound, definition used by Alvin Toffler. Toffler referred to technology as that "great growling engine of change." In an attempt to provide continuity within this yearbook, the Council on Technology Teacher Education's Yearbook Planning Committee requested that a common definition, used by the technology education profession and supported by the International Technology Education Association, be adopted. Technology, therefore, is defined as follows for purposes of this yearbook:

> A body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment. (Wright & Lauda, 1993, p. 3)

Science and technology are closely related and have a synergism that tends to enhance and support the development of each other. Stanley Kasprzyk, in his exhaustive study of the origin and place of technology (part of his doctoral dissertation at Michigan State University), stated that science is the study of the natural world and that it focuses on describing "what is" or "to know-that." Technology, on the other hand, focuses on "know-how" or the "rules of efficient action" and takes on the role of instrumental knowledge (Kasprzyk, 1973, p. 134). A model was developed by Kasprzyk to show the differences that exist between science and technology as illustrated by the forms of work. The model focuses on the aims, means, and consequences of the types of work that take place among the scientific, technological, and technical. Kasprzyk's model is shown in Figure 1–1.

Science focuses more on describing the natural environment and its laws, while technology focuses on the built environment and how people can best strive to live within it. One purpose of science, for example, is to describe the law of gravity in our natural environment. On the other hand, one purpose of technology or a rule of efficient action is to describe how to design and construct a suspension bridge in the built environment. DeVore (1980) believes that to differentiate between science and technology, one must first examine both the goals and scope of an activity in order to provide clarification to the differentiation. He states the following:

> If the *goal* of an activity is set by some specific human problem, the nature of the activity would be technological; where if the goal of the activity is based on curiosity and interest in finding basic generalizable theories, the activity would be scientific. If the *scope* of the problem is

FORMS OF WORK	AIMS		MEANS		CONSEQUENCES
Scientific work	Motivated by a cognitive or theoretical interest	To know that. . .	Methods, tools, and skills characteristic of discovery	Guided by systematic rules of inquiry	Theoretical knowledge in the form of theories and laws
Technological work	Motivated by a pragmatic or instrumental interest	To know how. . .	Methods, tools, and skills characteristic of invention	Guided by theoretic knowledge and by effectual practice	Instrumental knowledge in the form of systematized rules
Technical work	Motivated by a practical or productive interest	To do or produce	Methods, tools, and skills characteristic of production	Guided by systems of prescribed rules, or by rule-of-thumb	Things done or produced

Figure 1-1: Characteristics of scientific, technological, and technical work.

> clearly defined as solving a human or social problem within a specified environment, then the activity is technological. If, on the other hand, the goal of the problem, inquiry or activity does not restrict the scope of the results sought or the direction of inquiry, then in most cases the activity is scientific. (p. 243)

THE DISCIPLINE(S) OF TECHNOLOGY

Technology is seen from two different and very distinct views. The first view is derived from the early research in the field of industrial arts that described technology as a discipline. This view was supported by the work of Delmar W. Olson at Kent State University and Paul W. DeVore at the State University of New York–College at Oswego. Olson's landmark book entitled *Industrial Arts and Technology* (1963), analyzed some of the elements that would support describing technology as a discipline. DeVore (1968) followed the work of Olson by formally presenting the profession with the premise that technology meets the criteria for being an intellectual discipline. Outside the fields of technology education and the philosophy of technology, however, there appears to be little awareness, interest, or acknowledgment that technology is a discipline. Hence, the recognition of the outstanding work conducted by Olson, DeVore, and other individuals who followed them tends to remain within the internal literature of the technology education profession.

A second view of technology comes out of the field of study of engineering. While the engineering profession spends little time in defining itself through its various disciplines, it has evolved through widespread practice as a field with common disciplines including mechanical, electrical, civil, and chemical engineering, to name just a few. These have grown and matured, both through education and in industry, to have internal expectations, applications, standards, certifications, and professional associations. Through the practice of technology, engineering has also moved to the point where it has its internal accreditation through the Accreditation Board for Engineering and Technology, which is known by the acronym ABET. Technology can be viewed as a field of study that, like science, has disciplines within it. Science has, for example, the disciplines of biology, chemistry, and physics. If one was to follow this train of thought, technology and engineering have the disciplines of mechanical, electrical, civil, and chemical engineering, to name just a few. While the practice of technology through the engineering disciplines has evolved to its present status, Kasprzyk, in 1973, had already come to this same conclusion [that technology is made up of the engineering disciplines] when philosophically analyzing the field as a base for technology education. Bugliarello (1982, 1993) also identified technology as having many facets including that of being organized around the engineering disciplines. He states the following:

> Engineering can be viewed as the quest to extend our biological powers by creating artifacts – by modifying nature – by rational means. What started as the use of stick and pouches to carry food as we emerged as a distinct species has become the development of robots and spaceships. (1993, p. 206)

THE PROCESS OF TECHNOLOGY

There is a process of technology within which there are universals that can be identified, refined, taught, and practiced. Halfin (1973), in his dissertation conducted at West Virginia University and entitled, *Technology: A Process*, identified and validated this process for the profession. As identified by Halfin, it included the following universals:

- Defining the problem or opportunity operationally
- Observing
- Analyzing
- Visualizing
- Computing

- Measuring
- Predicting
- Questioning and Hypothesizing
- Interpreting data
- Constructing models
- Experimenting
- Testing
- Designing
- Modeling
- Creating
- Communicating
- Managing

Halfin's approach was undertaken to isolate the discrete universals of the process of technology. The resulting universals were validated by practitioners involved in these activities.

The process in the *study of* and in the *work with* technology can take on many forms. This process is an essential dimension of human experiences and takes on a wide array of potentials. Some elements of the process are of a technical dimension and others are more of a management/leadership dimension (Bensen, 1993). Those elements commonly associated with the technical dimension are inventing, solving problems, designing, and innovating. Those elements commonly associated with the management/leadership dimension are self-managing teams, total quality management, to name just a few.

While these technical and management/leadership elements of the process are not as focused in the actual intellectual elements that are used in the process, it is evident that they exist and that practitioners in these areas are involved in associations, regulations, and education. One of the most important aspects of the process of technology appears to be in the area of exclusiveness and protection, which results in formal documentation in the form of copyrights, logos, and patents (Bensen, 1992). For example, standards and measures of quality are monitored through organizations and bureaus such as the United States Patent Office, National Institute of Standards and Technology, Inventors and Designers Education Association (IDEA), Malcolm Baldrige Quality Program, ISO 9000, and Goldratt Institute, and through copyright laws, etc.

CHARACTERISTICS OF TECHNOLOGY

Perspectives of a Time Line

The history of the human race is rich in illustrations of how technology has impacted and shaped the world. Some societies have prospered while others have vanished as a result of the changes that have come about in technology. The history of technology is increasingly being revealed through the discovery of artifacts such as cave drawings. This history is permanently recorded and is made known partly through the discovery of the early tools and processes that people used to make their lives more stable, convenient, and safe. Early technology was relatively slow to transfer from one society to the next because of the isolation of these societies. Hence, one civilization often had to discover another in order to increase the chances of transferring technology back and forth between them. For example, while the wheel had been in use in Europe for many years, it was not used by the American Indian until it was introduced by the pioneers who had brought the technology to the colonies.

The development and use of technology continues today on a development track of ever increasing acceleration. The rate of change is reaching a level where it is bordering on the bewildering and is becoming an economic, political, and social force never before experienced by humankind. When discussing the rapid change being fueled by technology, people use terms such as half life, learning curves, being brought up to speed, and step-function change. Harkins and Winer-Cyr (1992) describe this incredible time as being "knowledge based." They go on to relate that the tremendous changes that people are confronted with as a result of the acceleration of change are such that "when a child is born today, by the time she or he is twenty one years old, the half life of a bachelor's degree will be one week" (p. i).

The past and the present serve as a foundation from which to look to the future. In technological terms, we have not seen anything yet. Sir Robert Telford, Life President of the Marconi Corporation, United Kingdom, illustrated this very point in his general session presentation at the 1992 International Conference on Technology Education in Weimar, Germany. He stated that "some 60% of the technology that will be used in industry in the year 2000 has not yet appeared. . . . today's sum total of knowledge is likely to equal only 1% of the total knowledge in the year 2050" (p. 93). The future brings with it tremendous opportunities for the technology education profession. The challenge to the profession, therefore, is to embrace these opportunities as the driving force for educational change in both the content being taught and the method of delivering learning experiences to students.

The Extension of the Human Potential

The potential of the human being, if we were to press our physical presence against mother nature, is indeed extremely limited. Humans, for example, can lift only so much weight, see so far in the distance, or hear a sound so well. If humans wish to lift more, see farther, hear better, or meet literally any number of a thousand other needs, they must extend their human potential through the use of technology. The extension of the human potential has reached virtually an unlimited ratio as humans set their course to accomplish such feats as moving mountains, charting the ocean floor, splitting the atom, transplanting human organs, and exploring outer space. One might ask, where will it end? Fortunately, it has no foreseeable end as humans pursue the solutions to difficult problems that they encounter each day, while using increasingly powerful, complex, and creative approaches.

People Creating Technology

Throughout history, people have created technology to satisfy their many needs. In the beginning, these needs focused on food, shelter, clothing, communications, transportation, and safety. When these needs were met, society moved to making life more convenient and satisfying. Other societies used technology to establish power, which allowed them to conquer and gain control over others. The history of technology is replete with examples of technology being used by humans in both positive and negative ways. One positive example is that people design appropriate clothes and shelters to fit their environments in order to protect themselves from the external elements. A negative example is the use of technology to gain control over others or even to destroy them.

Using technology to satisfy the wants of people can take on a wide range of perceived usefulness or appropriateness. When technology is used to make life more fulfilling or to expand access through communications or transportation, it is often assumed to be acceptable if it can be done with efficiency and economy. There are instances, however, when technology is used to satisfy wants that border on the outlandish and, in these cases, it often attracts the criticism of society (Samuelson, 1992). Sometimes the wants of people result in technological developments that are not user-friendly. This perceived complexity, when coupled with a level of technological illiteracy, results in statements such as that made by Gray (1992). She stated the following:

> Is nothing ever simple? As if you don't have enough to worry about you have to be a rocket scientist to record your favorite television show.

> Unequivocally not true, as millions have proved, but you think it is. And this anxiety, this phobia—this terror if you will—isn't only the VCR. It's the auto-defrost on the microwave, it's the CD player, it's voice mail, it's the photocopier. It's epitomized with the personal computer. It's technology. It's everywhere and it's not going to get any easier. Consider society becoming increasingly technological, and this becomes more and more of a serious problem.

The Impacts of Technology

Johnson (1992) states that technology can be viewed as both a technical process and a social process. In many cases an action that is accomplished by technology is measured by the impacts that it has on the social process. The social process, however, can work the other way as it calls on technology to solve problems that it is facing. The phrase, "necessity is the mother of invention," takes on expanded meanings when applied to technical and social processes. When one views the impacts of the technical and social processes of technology on the development of a culture over an extended period of time, technology becomes a powerful force that shapes generations upon generations. The impacts of technology on our society are pervasive and often subtle. Impacts may include, but are not limited to, trade-offs, safety and loss control, philosophy of technology, use/abuse, coping with rapid change, assessment, effects on the environment, and the common good. In order to be in control of our individual and societal decision making, people must be better able to understand technology. People gain assistance through the enforcement of standards and from organizations that assist in licensing and controlling technological impacts, including the Office of Technology Assessment, Occupational Safety and Health Administration, Federal Aviation Administration, and Federal Communication Commission (Bensen, 1992).

Values and Technology

Peoples' value systems influence the way they act and react within their environment. Technology is frequently the tool that is used in any action; hence, the relationship between it and peoples' values are inseparable. Melvin Kranzberg, the noted technology historian, believes that technology is neither good nor bad. People perceive technology as being good or bad, however, simply because the way it is applied in society. He further believes that technology opens doors to opportunities, but it doesn't compel people to enter them. It is imperative, therefore, that people become increasingly technologically literate and able to make better and more informed choices in the use of this know-how. Sometimes people may use technology in costly and complex ways to do what was once simple and inexpensive. Samuelson (1992), in his article "Technology in Reverse," refers to this situation as retarded technology, which is the opposite of advanced technology. According to Samuelson, retarded technology "creates new and expensive ways of doing things that were once done simply and inexpensively. Worse, it encourages us to do things that don't need doing at all. It has made waste respectable, elaborate, alluring and even fun" (p. 45).

INDIVIDUAL AND COLLECTIVE FORCES DRIVING THE TECHNOLOGICAL PROCESS

There are a number of forces that drive the technological process. Since technology is an intellectual process, it comes from humans, either individually or collectively. One driving force comes from the nature of technology itself, while another force comes from the level of literacy that a society has developed during any point in time. The adage that success contributes to more success is readily understood when observing the development of technology. The synergy that comes from building steadily on past technology can come incrementally or in major paradigm shifts. Many times the change is driven from a brilliant breakthrough by either individuals or groups who virtually change the world, such as when Edison invented the light bulb or a team of scientists split the atom.

The Nature of Technology

Technology fits, with its nature, into our culture as an integral and all encompassing force. As a result of technology, people find that they function not just in the natural environment, but also in a built environment. In the chapter on "The Nature of Technology" in the Project 2061 report entitled *Science for All Americans,* the following is stated about technology:

> In the broadest sense, technology extends our abilities to change the world: to cut, shape, or put together materials; to move things from one place to another; to reach farther with our hands, voices, and senses. We use technology to try to change the world to suit us better. The changes may relate to survival needs such as food, shelter, or defense, or they may relate to human aspirations such as knowledge, art, or control. But the results of changing the world are often complicated

> and unpredictable. They can include unexpected benefits, unexpected costs, and unexpected risks—any of which may fall on different social groups at different times. Anticipating the effects of technology is therefore as important as advancing its capabilities. (American Association for the Advancement of Science, 1989, p. 39)

Technological Literacy

How do people, both individually and collectively, participate fully in a technological society? It is assumed that for them to participate even minimally, they need a measure of technological literacy. Unfortunately, there has been very little agreement both within and outside of the technology education profession on what is meant by the term technological literacy. While extensive work has been conducted in this area, one of the more definitive research studies on technological literacy was conducted by Michael J. Dyrenfurth of the University of Missouri-Columbia. Dyrenfurth (1991) provides the following definition of technological literacy:

> Technological literacy is a concept used to characterize the extent to which an individual understands, and is capable of using technology. Technological literacy is a characteristic that can be manifested along a continuum ranging from *non-discernible* to *exceptionally proficient*. As such, it necessarily involves an array of competencies, each best thought of as a vector, that includes: Basic functioning skills, and critical thinking, construction work habits, a set of generalized procedures for working with technology, actual technological capability, key interpersonal and teamwork skills, and the ability to learn independently. (p. 179)

DOMAINS OF KNOWLEDGE AND HUMAN ADAPTIVE SYSTEMS

The Law of the Singular and the Plural

When describing a field of study or analyzing an activity, it is acknowledged that the outcome is unique to those who are involved in the process. One of the primary starting points in a philosophical discussion is the definition of the terms appropriate to the discussion. It may then be extrapolated that the more refined and delineated the statement of the problem, the easier the task becomes of going about solving it. The law of the singular and the plural is a useful tool, therefore, for those who are involved in studying technology and the education that is designed to transmit the knowledge, skills, and attitudes that are a part of the study.

If one were to initiate curriculum work by determining that technology is a singular concept, then all the breakouts and subsets would be a part of the whole and become, in a sense, universals. These universals would take the form of disciplines, systems, or process. On the other hand, if one were to deal with technologies (a plural concept), an encyclopedia approach would have to be taken and the issues that address holistic outcomes would not be a primary concern. Technology education curriculum work, when approached in the plural sense, takes more of an approach of identifying the common technologies, listing them, and often prioritizing them. When taking the plural approach, one tends not to be as concerned about whether or not the "big picture" of technology has been included. It is the observation of many people in the technology education profession that when the educational approach to the singular concept is initiated, general education is the focus of the orientation. When the educational approach is plural, education tends to be more utilitarian, focusing on such areas as education for work.

Knowledge and Systems

Professions pass through key periods throughout their history, when landmark decisions and actions that effect change and result in significant improvement in the field take place. One of these significant periods for the technology education profession occurred during the Jackson's Mill project. The work of the key individuals in that endeavor resulted in the publication entitled the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981). (See Chapter 7 for a more complete description of the Jackson's Mill project and publication.) The work of the group provided a consensus that had been lacking in the profession for many years. The Jackson's Mill study continues to this day to serve the profession as a source of needed direction in curriculum design. One result of the Jackson's Mill project was the provision of a curriculum theory that brings the domains of knowledge and human adaptive systems into an interactive and mutually supportive model.

The mutual interactive model is shown in Figure 1–2. It is through the interaction of the domains of knowledge and an understanding of how people use systems to adapt to their environment that the power of this model is recognized. It is an all-inclusive model that takes the broadest view of both of its dimensions (Snyder & Hales, 1981).

A review of the multi-dimensions of the interactive model provides evidence that human activity relating to the study of technology contributes

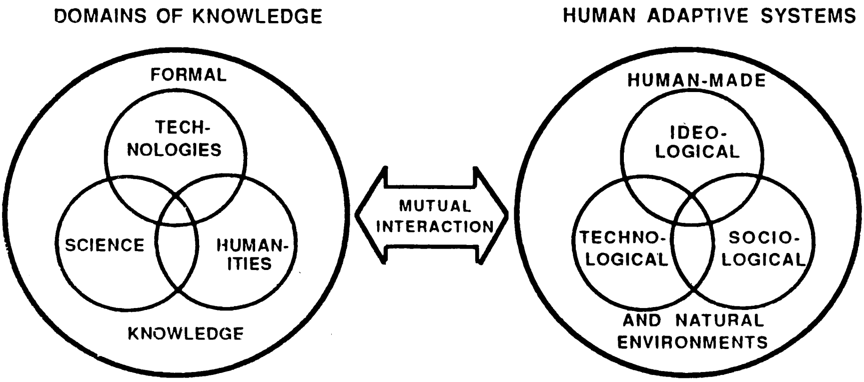

Figure 1-2: Mutual Interactive Model.

to the domain dimension of technology. The knowledge base from which to understand better the know-how of the world around us therefore grows. Human activity involved with the application of technology to increase human capability for control over the natural and built environments results in increases in our adaptive systems. As these two dimensions of the model increase in their ability to interact, both dimensions of the model benefit.

In follow-up work to the Jackson's Mill project, Leonard F. Sterry of the University of Wisconsin-Stout and R. Thomas Wright of Ball State University coordinated a study to operationalize the theory that had been developed by the Jackson's Mill participants (Wright & Sterry, 1983). Through the collective efforts of 10 technology educators in the field, *Industry and Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers* was developed, published, and distributed to the profession. In a later development, *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990) was developed, published, and made available at a nominal cost through the International Technology Education Association. This publication was a result of the collective efforts of 25 technology educators who, through their endeavors, assisted the field in refining its theory. One of the key contributions in this study was the presentation of the Technological Method Model.

The Technological Method Model as shown in Figure 1–3 provides a conceptualization closely related to the process discussed earlier in this chapter. The model relates to how humans work through problem-solving endeavors. It is through these systematic approaches in life that people are able to identify the rules of efficient action and improve in their ability to apply technology.

Some of the common organizers for use in the identification of content for technology education programs are often categorized into systems such

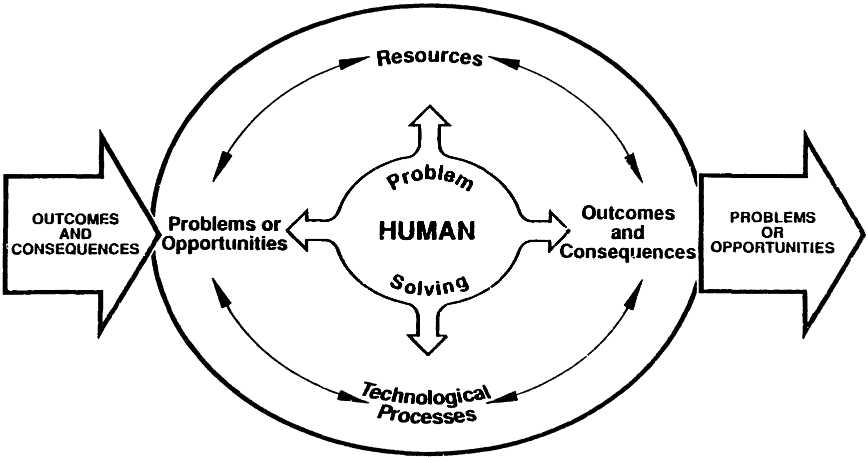

Figure 1-3: The Technological Method Model.

as communications, manufacturing, transportation, and construction. (Just as we have associations, councils, and accreditation boards for the various disciplines, we have other professional groups for systems or human endeavors, e.g., National Association of Industrial Technology [NAIT], American Institute of Plant Engineers [AIPE], Association for Production and Inventory Control [APICS], Society of Automotive Engineers [SAE], and Society of Manufacturing Engineers [SME], The Associated General Contractors of America [AGC], to name just a few.) These systems-oriented human endeavors become more dynamic each day as we experience the interrelating of the traditional disciplines of engineering with the cross-discipline approach of applying systems.

TECHNOLOGY EDUCATION

A Current Definition

As one studies this yearbook, it will become readily apparent that technology education has a rather short history when viewed from the perspective of the total history of education. In a formal sense, the most recent impetus for technology education came about as the result of the initial efforts of the Jackson's Mill participants. Many individuals and groups, including professional associations at all levels of education, have capitalized on the efforts of the Jackson's Mill group to define technology education better. In a publication entitled *Technology Education: A Perspective on Implementation*, the International Technology Education Association (ITEA), for example, defined technology education as "a comprehensive, action-based educational program concerned with technical means, their evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources and products; and their social/cultural impact" (1985, p. 25). In a 1990 publication by the ITEA entitled *A Conceptual Framework for Technology Education*, a more succinct definition of technology education was presented: "Technology education. . . is the study of technology and its effect on individuals, society, and civilization" (Savage & Sterry, 1990, p. 20). The most current definition of technology education by the ITEA appeared in the January 1993 edition of *The Technology Teacher.* This definition stated that technology education is "an educational program that assists people [to] develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (Wright & Lauda, 1993, p. 4). For purposes of this yearbook, this latter definition will be accepted.

Achieving a Reading on the Future

Societal change is both continuous and pervasive. In the field of technology, change is also dynamic and accelerating; it is a powerful force in shaping the very world and societies within it. It is important, therefore, that the technology education profession continue to read the future and focus on well established trends. The importance of this view was articulated in the study entitled, *Technology Competence: Learner Goals for All Minnesotans:*

> This accelerating pace of change affects not only the lives of individuals but also the destinies of whole nations. The globalization of markets has been brought about by advances in the technologies of communication and transportation. The pace and scope of technological development challenge all of our social, economic, and political institutions. Now, more than ever, wise consideration of the use and development of technology is required to ensure the well-being of all of us and the planet which we share. (Zilberg & Mercer, 1992, p. 1)

A Rationale

The very essence of peoples' ability to live safe, enriched, and satisfying lives depends upon the control they have over the forces that impinge upon them and the resultant quality of life that is thereby generated. This wealth, both individually and collectively as a nation, rests in peoples' capability and potential to improve upon their present status. Technology is one of the most powerful forces that people have at their disposal, as a leverage for themselves and as a potential gain in a multitude of dimensions.

It is technology, therefore, that serves as the multiplier of productivity and as a leverage in preparing people for a better tomorrow. The study of technology, and the understanding and know-how that comes with it, is central to its relevance for all education. The publication, *Technology: A National Imperative*, focuses on this critical issue.

> Herein lies the crucial need for a national strategic approach to restructuring the educational systems of the United States. Such a restructuring would provide individuals with the basic thinking and creative skills required in the 21st Century: Communications, problem-solving, scientific and technological literacy. The key for economic competitiveness in the global marketplace today and in the future is "*productivity*." This can only be accomplished if we have excellence in Technology Education. (Technology Education Advisory Council, 1988, p. 3)

John Goodlad brings a fresh look at the complexity of education when he refers to himself as being only "half educated" (Goodlad, 1992). He states that even though he has a Ph.D. from the University of Chicago and has been a professor at a number of universities throughout his career, he sees himself as only half educated, while at the same time society regards him as well educated. He believes that this is a result of our society having a limited view of what education encompasses. Goodlad states the following:

> Today, I need a corps of representatives of the other half to keep the Goodlad family afloat. . . . We need an array of specialists: to make car and boat engines healthy once more, to stain the house's exterior periodically, to repair its heat pump, to fix innumerable gadgets that don't live up to their advertised excellence. (p. 34)

This missing dimension of the education and experience of a rather significant growing segment of our society was identified in a Minnesota study and is proposed as what is needed to be technologically competent. The dimension falls into the two components of *world view* attributes and *practice* attributes as identified by Zilberg and Mercer (1992):

The world view attributes include the following:

- Systems View of Technology
- Lifelong Learning About Technology

- Global Perspective of Technology
- Historical Perspective of Technology

The practice attributes include the following:

- Acquiring and Managing Information About Technology
- Communicating and Technology
- Ethically Using Technology
- Relating Technology to the Arts, Humanities, and Social Sciences
- Relating Technology to Mathematics and Science
- Developing, Selecting, and Using Technology
- Creating Solutions through Technology
- Critically Evaluating Technology
- Relating the Common Good to Technology (pp. 7–11)

The Primacy of Approach

The study of technology has taken a number of differing approaches, some determined by the level of the instruction and others by the particular viewpoint of the developers. Primacy program approaches that have been most popular in the organization of programs that focused on technology have been in the areas of learning behaviors, technological concepts, problem solving, and technological systems.

In the behavior-of-learners approach to studying technology, the program is designed around the behaviors that are determined to be essential for people living in a technological society. These essential behaviors are commonly identified as those being associated with being a citizen, purchaser, consumer, home owner, and communicator, to name just a few. The intent of this approach is to provide a set of experiences that would ensure a substantial improvement in the life-style and self-fulfillment of the individual.

The concepts-of-technology approach to the structuring of programs focuses on the major universals of the discipline and the subsets of these concepts. In some cases, these concepts are identified and organized into a taxonomy. DeVore (1968) provided one of the earliest of these for the profession. His taxonomy is shown in Figure 1–4. The solving-of-technological problems approach takes on differing models in program structure. One of the more prominent programs developed using the

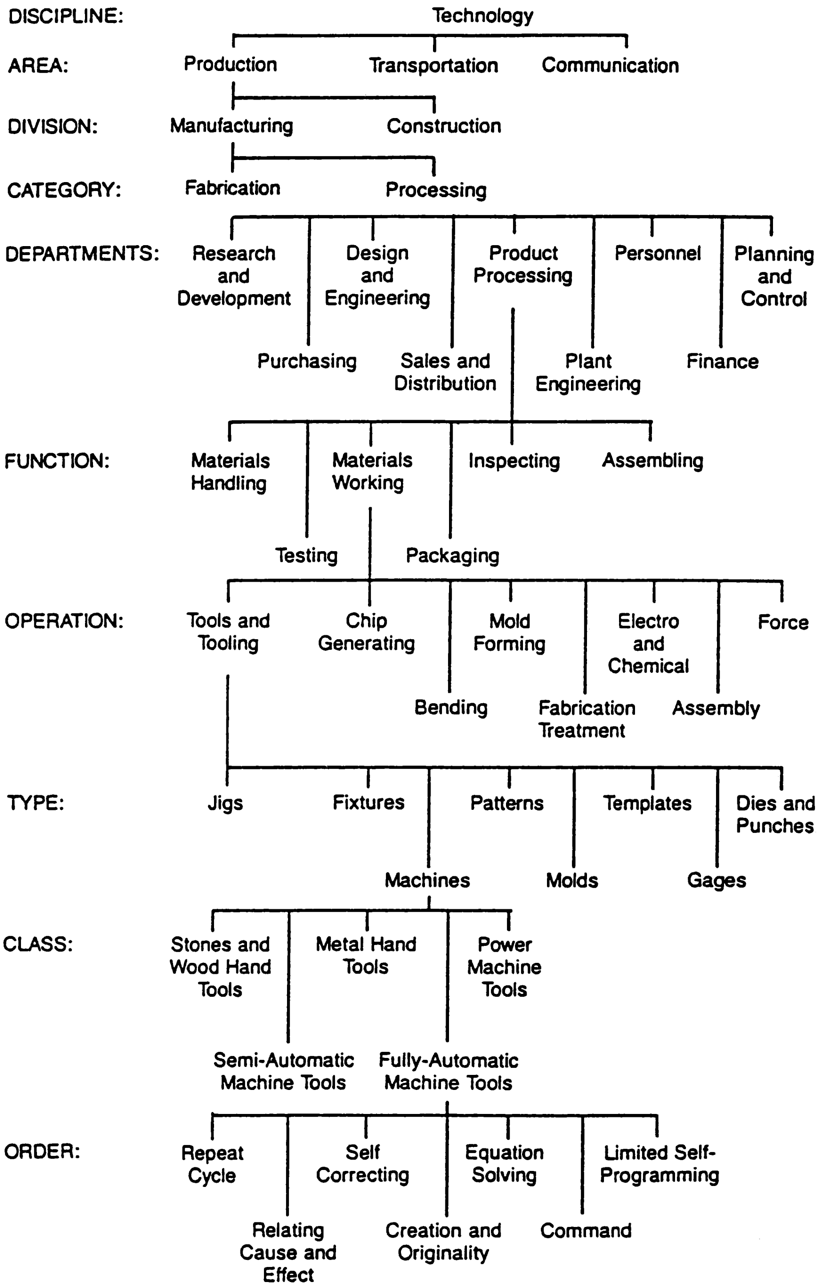

Figure 1-4: Conceptual model of technology.

problem-solving mode was the Maryland Plan as developed by Donald Maley at the University of Maryland. The Maryland Plan (1973) focused on reviewing technological approaches involving tools and machines, power and energy, and transportation and communication. In addition, this program used a time line of the past, present, and future in structuring the problems in which students were engaged. Technological problems incorporated in an anthropological approach to the study of certain basic elements common to all civilized mankind were a common seventh grade experience; a contemporary approach to the study of modern industry was part of the eighth grade experience; and research and development problems for studying the future were a common ninth grade experience.

The technological systems approach in the design of technology education programs currently has gained the most acceptance by practicing technology education teachers throughout the country. Many states have approved program plans based on this approach. The technological systems generally include communications, production, and transportation, and their subsystems. In some programs, the production systems area is subdivided into construction and manufacturing systems.

Design and Technology

The design-based technology programs of the United Kingdom have grown in popularity and have spread to other countries, particularly in Europe. The interest in design-based technology programs has received growing attention in the United States and is described by Todd and Hutchinson (1992) in their article "Design and Technology: Good Practice and a New Paradigm." These programs differ from those that focus primarily on technology, as described in a survey conducted by *Technology, Innovation and Entrepreneurship for Students*. A comparison of technology and design and technology programs is shown in Figure 1–5.

OPPORTUNITIES FOR INTEGRATION

Robert Gauger, while seeking ways to enhance the academic learning of students, experimented with the use of technology to support the teaching of science. He developed technology laboratories to be taken in conjunction with the traditional science courses. Students who were enrolled in a chemistry course, for example, could also elect to enroll in a chemical technology laboratory course. In a follow-up evaluation, students who enrolled in a technology laboratory course along with the parallel science

	TECHNOLOGY	DESIGN & TECHNOLOGY
Its subject matter is	Technological systems	Human needs & wants
Its goal is	Technological literacy	Technological capability
Its objectives are	Concept-oriented	Holistic: Living by design
Its focus is on	Principles & thinking	Principles, values, & thinking
Its activities are	Group-centered	Hands-on/minds-on
Its methods are	Problem solving & transformation	Design-oriented

Figure 1-5: A comparison of programs.

course almost doubled their post-test scores in their science courses (Gauger, 1992).

There is a growing movement throughout education to seek ways to integrate programs in order to make them more meaningful, useful, and better understood. The use of technology education programs to serve as integrators has tremendous potential. In a paper offered as a response to the Technical Foundation of America's 1992 Symposium on Critical Issues in Technology Education, the author proposed a model that depicts the wide range of the study of technology through its disciplines, systems, process, and impacts (Bensen, 1992).

SUMMARY

Technology is a powerful force that shapes individuals and societies in a pervasive, subtle, and relentless fashion. Societal initiatives have burst into the decade of the 1990s with tremendous momentum, fueled by a technology that seems to change the rules every time we turn around. The education needed to be culturally literate today requires more than a casual measure of technological competence. In fact, people are considered not to be well educated unless they understand the culture in which they live. We are in a highly advanced technological society, and having a world view and an understanding of the practice elements of this culture is central to being competent people. Anything less places us in this global society as second rate citizens. Now the challenge is before us and we must meet it.

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CHAPTER 2

Technology Education and Other Technically Related Programs

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Technology education co-exists with several other technically related programs at the elementary, secondary, and higher education levels. The industrial component of vocational education (trade and industrial education), technology education, and other technology interdisciplinary programs exist in varying degrees K–12 programs in public and private schools. Technology teacher education, vocational trade and industrial teacher education, industrial technology, engineering technology, and engineering programs exist in higher education.

Technology education, technology teacher education, vocational trade and industrial education, vocational trade and industrial teacher education, industrial technology, engineering technology, and engineering are all different technical academic fields. Within each of these fields, there are a variety of areas of study. This organizational complexity can cause confusion if the different technical academic fields are not thoroughly understood.

This chapter examines the similarities and differences among technically related baccalaureate degree programs. Understanding these similarities and differences can assist people when selecting a major field of study. The type of technical career being sought usually determines the advanced degree level that may be required for entrance into the career. High school graduates interested in pursuing vocational education programs, for example, usually attend a career school, technical college or institute, or community college, and upon successful completion, receive a certificate, diploma, or an associate degree. High school graduates who wish to pursue teaching in a technical field may become a technology education teacher by

Profession	Technology Education Teacher	Vocational-Trade & Industrial Education Teacher	Employed in a Technical Profession in Industry, Business, or Government as an: Industrial Technologist	Engineering Technologist	Engineer
Baccalaureate Program	Technology Teacher Education (TTE)	Vocational-Industrial Education (VTE)	Industrial Technology (IT)	Engineering Technology (ET)	Engineering (ENG)
Definition and/or Description	TE	VE and VTE	IT	ET	ENG
Historical Evolution	TE from Industrial Arts (IA)	VE	IA, Education for Industry, and VTE programs	Technical Institutes	Engineering
Mission, Goals, or Principles	Prepare Technology Education Teachers and Supervisors	Prepare Trade and Industrial Education Teachers and Supervisors	Prepare Industrial Technologists	Prepare Engineering Technologists	Prepare Engineers
Curriculum Components	General Education, Technology, Technology Systems, Professional Education	General Education, T&I Specialty, Professional Education, Industrial Experience	General Education, Technical System, Technical Management	General Education, Math and Science, Technical Specialty	General Education, Calculus and Calculus-based Science, Engineering Science, Technical Specialty
Major Administrative Unit	College of Technology or Applied Science, College of Education	College of Technology or Applied Science, College of Education	College of Technology or Applied Science, College of Engineering	College of Engineering, College of Technology or Applied Science	College of Engineering
Typical Entry Level Career Titles	Manufacturing Technology Teacher, Communication Technology Teacher, etc.	Automotive Teacher, Building Trades Teacher, Electronics Teacher, etc.	Industrial Technologists (Computer-Aided Design, Construction, Manufacturing, etc.)	Engineering Technologists (Automotive, Chemical, Civil, Construction, etc.)	Civil Engineer, Chemical Engineer Mechanical Engineer, Manufacturing Engineer, etc.
Place of Employment	Public or Private Schools	Comprehensive High Schools, Community Colleges or Technical Institutes	Industry	Industry	Industry

Figure 2-1: Matrix showing a comparison of technology education with other technically related programs.

majoring in technology teacher education or they may become a vocational trade and industrial education teacher by majoring in vocational trade and industrial teacher education. Four year degree programs designed to prepare graduates for employment in industry include industrial technology, engineering technology, and engineering.

These different baccalaureate degree programs require that a person understand the definition, history, mission and/or goals, curriculum components, administrative organization, and challenges of a desired baccalaureate major. A person also needs to be knowledgeable of typical positions of employment, professional associations, certification requirements, and opportunities for advanced degrees. Technology education and vocational trade and industrial education teachers need also to understand the different curricular and administrative organizational patterns that exist in public education programs.

TECHNOLOGY EDUCATION AND TECHNOLOGY TEACHER EDUCATION

Technology teacher education baccalaureate degree programs prepare people to teach technology education at the elementary school, middle school or junior high school, and/or high school levels. Certification requirements for technology education teachers are determined by state departments of education, whose organizational structures vary from state to state. In some instances, state departments of education have a subject matter supervisor within a specific division or section, such as secondary education, who assumes responsibility for technology education. In other states, vocational trade and industrial education supervisors may oversee both technology education and vocational education.

Definition and History of Technology Education

Technology education evolved from industrial arts. During the 1970s and 1980s, extensive debate among professional educators took place in the United States on whether the subject matter base for industrial arts should be industry or technology and on the appropriateness of existing curriculum approaches for teaching technology. The *Jackson's Mill Industrial Arts Curriculum Theory* publication determined that the focus of industrial arts should be on the study of industry and technology and their impact on society and culture (Snyder & Hales, n.d.). This report also noted that industrial arts should include the human productive activities of communicating, constructing, manufacturing, and transporting (Snyder & Hales, n.d.). As a result of the greater emphasis placed on the study of technology, the American Industrial Arts Association (AIAA) changed its name to the International Technology Education Association (ITEA) on March 26, 1985 at its annual conference in San Diego, California. (The recent history of technology education is reviewed in Chapter 7 of this yearbook.)

Technology education is perceived as a process of educating people about technology. Technology, as the subject matter of technology education, ". . . is a body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment" (Wright & Lauda, 1993, pp. 3–5). As noted by Bensen in Chapter 1 of this yearbook, technology, in theory, is perceived as being singular or holistic with universal characteristics or attributes. Some examples of universal attributes of technology identified by Israel and Lauda in *A Conceptual Framework for Technology Education* are the following:

- People create technology.
- Technology responds to human wants and needs.
- People use technology.
- Technology involves actions to extend human potential.
- The application of technology involves creating, implementing, assessing, and managing.
- Technology is implemented through the interaction of resources and systems.
- Technology exists in a social/cultural setting.
- Technology affects and is affected by the environment.
- Technology affects and is affected by people, society, and culture.
- Technology shapes and is shaped by values (Savage & Sterry, 1990, p. 11).

Technology education, when perceived as a knowledge of action, ". . . is an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (Wright, Israel, & Lauda, 1993, p. 6). Major technological actions encountered are the following: (a) developing and designing technological artifacts and systems, (b) using tools and machines to produce a system or artifact, (c) using the products and/or services of technological systems, and (d) assessing the impacts of technology on society, the environment, and the culture. (See Chapter 7 of this yearbook for a more complete discussion of this topic.) This definition allows curriculum developers to use a number of content organizers: communication, construction, manufacturing, and transportation (Snyder & Hales, n.d.), bio-related, communication, production, and transportation (Savage & Sterry, 1990), or other organizers as identified in state curriculum guides.

Goals of Technology Education

Graduates of technology teacher education programs are usually licensed to teach technology education from grades K–12. The mission of technology education at these grade levels "is designed to help students understand and to participate in the technological society today and tomorrow" (Wright, Israel, & Lauda, 1993, p. 6). The ITEA has taken the following position:

> Because the American culture is distinctly characterized as technological, it becomes the function of schools to give every student an insight and understanding of the technological nature of the culture. This is what the program of technology education strives to do. It acquaints all persons with their technological environment so they can make rational decisions about their own lives on a day-to-day basis and eagerly participate in controlling their own destiny. (International Technology Education Association, 1985, p. 25)

In summary, it is noted that "technology education is a basic and fundamental study for all persons, regardless of educational or career goal" (International Technology Education Association, 1985, p. 25).

Wright, Israel, and Lauda (1993) stated that a student who has completed a technology education program should be able to participate as an active citizen by expressing their positions on technological issues, making wise consumer choices such as selecting, using, and disposing of technical artifacts, and making informed career choices. Technology education helps students in becoming technologically literate and competent as shown by their ability to do the following:

- Select appropriate technological products and services to meet personal and group needs.
- Understand how technology is used in producing products and services.
- Effectively communicate technological information and ideas.
- Describe technology in a historical and evolving societal context.
- Use problem-solving, decision-making, invention, and innovation to design technological devices and systems.
- Effectively use tools, materials, and machines to produce technological devices.

- Appropriately select, operate, maintain, and dispose of technological devices.
- Assess the personal, social, economic, and environmental impacts of technology.
- Use appropriate personal and interpersonal skills in participating in the technological society as a citizen/voter, consumer, and worker (Wright, Israel, & Lauda, 1993, p. 7).

Technology Teacher Education Curriculum Components

The Council on Technology Teacher Education (CTTE), a council of the International Technology Education Association (ITEA), has as one of its major goals "to define and strive to achieve the purposes and professional goals of technology teacher education, and to enlist the greatest possible number of people in this endeavor" (Council on Technology Teacher Education, 1993, p. 1). The CTTE, working in cooperation with the ITEA and the National Council for Accreditation of Teacher Education (NCATE), developed guidelines for reviewing technology teacher education programs.

The NCATE accredits teacher education units. As part of the accreditation process, subject matter learner societies, such as those that represent technology education, can establish guidelines for the review of technology teacher education programs. Each program to be reviewed submits a folio that identifies how their program meets the guidelines. Evaluation criteria are employed and the program is either found to be in compliance, in compliance with stipulations, or in noncompliance.

The CTTE/ITEA/NCATE technology teacher education folio requirements consist of three major components: (a) overview and scope of the program, (b) guidelines and matrix, and (c) appendices (Council on Technology Teacher Education, 1992). The guidelines and matrix section of the folio identifies curriculum components that should be included in a technology teacher education program. For example, undergraduate programs must include general education, teacher education, and specific subject matter components. The CTTE/ITEA/NCATE technology teacher education guidelines require evidence of appropriate mathematics, science, and general studies related to the study of technology (Council on Technology Teacher Education, 1992). In addition, some state teacher certification/licensure and/or teacher education graduation requirements may include speaking, reading, and/or writing examinations.

The subject matter component of technology teacher education should include fundamental knowledge about the development of technology and its effect on people, the environment, and the culture (Council on Technology Teacher Education, 1992). In addition, the component must include technical and instructional content for developing, producing, using, and assessing technology in communication, construction, manufacturing, and transportation, or other technological organizers as recommended by a technology education state curriculum plan. Prospective teachers must be able to show evidence that they can operationalize the organizers using contemporary equipment, procedures, processes, and systems, as well as achieve a desired minimum level of performance in the use of tools, machines, and equipment. Professional technology teacher education courses should enable prospective teachers to do the following: (a) develop a proficiency in planning, implementing, and evaluating technical problem solving experiences, (b) use activity-oriented laboratory instruction with students that reinforce abstract concepts with concrete experiences, and (c) use other areas of knowledge, such as mathematics and science, to help solve technical problems (Council on Technology Teacher Education, 1992).

The general teacher education component includes pre-student teaching experiences, usually referred to as clinical or field experience, a student teaching experience, with or followed by a culminating experience such as a practicum or post-student teaching seminar. While completing the teacher education experience, students are required to take courses related to the philosophy of education, history of education, social aspects of education, psychology of learning, human development, the teaching of reading, general methods of teaching, evaluation and assessment, and curriculum planning. State certification may require specific topics in given courses or whole courses devoted to special education and/or multicultural diversity. Accreditation guidelines, state certification requirements, and university teacher education requirements are used to determine teacher education admission requirements, student teaching requirements, and graduation and/or state certification requirements. Some state departments of education require a minimum performance level on pre- or post-general education and/or subject matter exams (Council on Technology Teacher Education, 1992).

The CTTE/ITEA/NCATE folio guidelines specify that technology teacher education graduates must be able to analyze the philosophy of technology education, articulate and promote technology education, and write appropriate psychomotor, affective, and cognitive objectives and use them to monitor student performance. They must also be able to do the following: (a) plan, implement, and evaluate technology education units of instruction, (b) identify and select content, develop laboratory experiences, and plan facilities for implementing technological system organizer courses to achieve the program's goals and objectives, and (c) select and develop appropriate instructional strategies for group and individual instruction. Graduates must also be able to do the following: (a) integrate specific safety instruction, (b) manage instruction and facilities for technology education, (c) develop, implement, and manage student organizations, (d) plan and implement personal plans for professional development, and (e) use the *Standards for Technology Education Programs* to evaluate, revise, and improve technology education programs (Council on Technology Teacher Education, 1992).

The CTTE/ITEA/NCATE folio guidelines note that the teacher education component for planning, implementing, and evaluating technology education must include specialized instruction for classrooms and laboratories for the study of technology, both in individual and group settings. The designing and evaluating of learning experiences must result in grades K–12 or 5–12 students understanding the role of technology in the environment, society, and culture and the nature of the major subject matter organizers of technology. In addition, students must demonstrate technical competencies under the supervision of a technology teacher education faculty member and a master teacher in a school setting (Council on Technology Teacher Education, 1992). University or college of education teacher education faculty councils, made up of representatives from different subject matter areas such as technology education, usually determine the policies, nature, and delivery of the general professional education component. The technology teacher education faculty are usually responsible for providing, supervising, and evaluating the professional sequence that is unique for preparing technology education teachers.

Administering Technology Teacher Education Programs

There are different organizational structures for administering technology teacher education programs. For example, programs are housed in a separate department or division of a college of education or in another college such as college of professional studies, college of technology, college of engineering and technology, college of applied science, college of applied science and technology, or college of agricultural science and technology. Some technology teacher education programs are not housed in a college of education because of the need for universities to pool resources for the delivery of technical laboratory-based programs that are often more expensive than classroom-based programs. It is common, therefore, for one department to administer a number of technical programs such as the following: (a) technology teacher education, industrial technology, and trade and industrial education, (b) technology teacher education, vocational teacher education, and industrial training, and (c) technology teacher education, industrial technology, and engineering technology. The advantage of such an arrangement is that each program shares faculty resources and laboratories. The disadvantage is that the goals and objectives of the different technical programs and courses are usually not appropriate for the technology teacher education program.

Typical Careers in Technology Education

Teaching employment opportunities in technology education exist at the elementary school, middle school, junior high school, and senior high school levels and generally provide an opportunity for a teacher to earn tenure. Administrative positions in technology education include the following: (a) coordinating middle school, junior high school, and high school technology education programs, (b) administering a technology education program for a school district, and (c) supervising technology education for a large school district, county, or intermediate school district. Post-secondary positions may include becoming a teacher education faculty member or a state technology education supervisor or director.

Advanced Study, Associations, and Certification

All states require certification as a teacher, with requirements varying among the different states. Some states require the completion of a given number of semester hours of appropriate courses, successful performance on standardized subject matter exams, and/or completion of an advanced degree in a given time period for continued certification. Advanced degrees in or related to technology education are a master's of education or a master's of science in technology education and a doctor of education or a doctor of philosophy in education or in a related educational field.

The ITEA is the national professional association that represents technology education at all levels. It has three councils: the CTTE, the Technology Education for Children Council (TECC), and the ITEA Council of Supervisors (ITEA-CS). (A complete description of the councils is found in Chapter 18 of this yearbook.)

Scope and Sequence of Technology Education

Technology education in grades K–12 is typically divided into three or four different levels based upon the school system: elementary or early childhood (K–3), upper elementary (4–6), middle school (6–8) or junior high school (7–9), and high school (9–12 or 10–12). At the K–3 grade level, technology education helps reinforce student learning in other subject matter areas through activity learning and it introduces students to tools, materials, processes, and technological systems. Technology education also helps students understand basic technological concepts such as human needs and wants, mass production, communication, and transportation. At grade level 3–5 or 3–6, technology education makes students aware of the role of technology in the environment, society, and culture through designed classroom and/or laboratory experiences or through the interdisciplinary study of related subjects that include the study of technology (International Technology Education Association, 1985).

At the middle or junior high school level, students are usually required to take technology education. At this level, students learn how new technology is created, how technological systems are developed to provide goods and services, how technological devices and services are used, and how the effect of technology upon the environment and people is assessed. The content organizers of bio-related, communication, construction, manufacturing, and transportation may be used to study technology at this level (International Technology Education Association, 1985). The goal at the high school level is to help students understand the four technological actions of developing, producing, using, and assessing in one or more of the technological organizers. An introductory course for each organizer is generally followed by in-depth courses related to each system. Some examples of learning experiences at this level are the following: (a) developing a device or writing a procedure for solving a problem in manufacturing, (b) developing and implementing a manufacturing system to

	TECHNOLOGICAL ACTION			
Technology Education Organizers	**Developing**	**Producing**	**Using**	**Assessing**
Communication	X	X	X	X
Construction	X	X	X	X
Manufacturing	X	X	X	X
Transportation	X	X	X	X

Figure 2-2: A curriculum plan for organizing a high school technology education program (Wright, Israel, & Lauda, 1993, p. 36).

produce a product or to provide a service to meet a given need, (c) using, maintaining, and/or disposing of a technological system or device, product, or service, and (d) assessing the effect a new sequence of steps in a manufacturing system has on the environment (International Technology Education Association, 1985).

VOCATIONAL TRADE AND INDUSTRIAL EDUCATION AND TRADE AND INDUSTRIAL TEACHER EDUCATION

Vocational education, as described by the American Vocational Association, is an educational area that encompasses a variety of programs designed to equip students with work and life skills. Vocational programs assist individuals to explore career options and develop occupational skills in high schools, community colleges, and technical institutes (American Vocational Association, n.d.). "The vocational curriculum's unique combination of classroom instruction, hands-on laboratory work and on-the-job training—augmented by an active network of student organizations—gives students the practical experience they need to succeed in such diverse fields as agriculture, computer science, retail sales, and high-tech manufacturing" (American Vocational Association, n.d., p. 1). Vocational education serves as a springboard for immediate employment after high school and prepares people for continual retraining, post-secondary education, and college (American Vocational Association, n.d.).

The implementation of vocational education requires that each state department of education file with the United States Department of Education an approved plan to receive federal funds. The state plan must meet federal guidelines and include approved state matching funds. Recent changes in federal guidelines have placed greater emphasis on career exploration, meeting diverse population and special educational needs, identifying basic and advanced skills for a number of related clusters of occupations, integrating related technical subject matter areas, integrating vocational education with academic subject areas, preparing people for high-technology positions, and articulating high school and post-secondary programs.

Vocational education is divided into different occupational fields. They are the following:

- Agriculture, including horticulture, agricultural mechanics, and agribusiness.

- Business education, including accounting, office occupations, and business management programs.
- Health occupations, such as practical nursing, nursing, medical and dental assistants, and radiologic technicians.
- Home economics, which encompasses consumer and homemaking education as well as occupational fields such as food services.
- Marketing education, including general merchandising, apparel and accessories marketing, real estate, financial services and marketing, business, and personal services.
- Technical education, which involves a variety of technical occupational fields, such as communications, engineering-related technologies, and computer science.
- Technology education, which concerns materials, processes, and technologies used in manufacturing, construction, transportation, communication, and other industries.
- Trade and Industrial education, which includes a wide range of trades, including auto mechanics, carpentry, metalworking, graphic arts, and cosmetology. (American Vocational Association, n.d., p. 3)

The study of different industrial fields within vocational education includes technical education, technology education, and trade and industrial education. Vocational trade and industrial teacher education programs prepare teachers for gainful employment in technical education and trade and industrial education.

There are significant differences among trade and industrial education, technical education, and technology education. Trade and industrial education prepares high school graduates for a variety of occupational and trade positions. This may be accomplished through a comprehensive high school or a vocational education center that services more than one high school. Certification to teach vocational trade and industrial education usually requires a combination of occupational experience and college academic preparation.

Technical education is associated with post-secondary programs that are funded by vocational education. These programs exist in career schools, technical colleges or institutes, and community colleges, with community colleges having experienced tremendous growth in technical education programs during the past 20–30 years. A community college technical program, for example, may include one- or two-year certificate programs and associate of applied science degree programs in areas such as construction, computer aided drawing, computer assisted manufacturing, electronic technology, manufacturing metallurgy, quality assurance, robotics, and welding. These programs may be housed in administrative units with titles such as trade related, technical education, industrial technology, and/or engineering technology. A comprehensive review of post-secondary technical education is beyond the scope of this chapter.

The goals of vocational education often cause technology education to be perceived as being prevocational—providing a broad background in different fields of technical study such as communication, construction, manufacturing, and transportation. Technology education, therefore, as part of vocational education, provides students with an orientation to high school trade and industrial education programs and post-secondary technical education programs. Many middle school, junior high school, and high school technology education programs may serve as prevocational programs for high school vocational trade and industrial education and technical preparation (tech prep) programs. Vocational technology education courses or programs may be taught by certified technology education or trade and industrial education teachers. A prevocational program, which is part of a high school curriculum, generally requires a teacher to have a baccalaureate teaching degree. Vocational technology education courses or programs, as part of a high school vocational education program, could be taught by a trade and industrial education teacher or a technology education teacher, depending upon the vocational education state certification requirements.

The Meaning of Industrial Education

Industrial education has been used with many different meanings throughout the history of education in the United States. In some cases, its meaning is specific to a particular geographical region of the United States. Four different uses of the term are the following:

1. Industrial education includes industrial arts and the industrial fields of vocational education—trade and industrial education and technical education.
2. Industrial education encompasses only the industrial fields of vocational education and does not include industrial arts.
3. Industrial education is used in place of trade and industrial education at the high school and undergraduate levels because the term trade is perceived as being inappropriate.
4. Industrial education refers to all industrial teacher education programs that prepare teachers for high school trade and industrial

education and post-secondary technical programs. In this context, industrial teacher education may include preparing trainers for industry and/or the military.

An operational definition of the term industrial education typically does not include technology education, but from a vocational education perspective, there is logic for including technology education in the definition. Technology education, as noted previously, is perceived as being required by all future citizens in order that they may better understand the role of technology in their society and culture and its effect on the people and the environment. From a vocational education viewpoint, technology education is that part of industrial vocational education that provides an overview and/or orientation to major industrial activities, such as communication, construction, manufacturing, and transportation, at the middle school, junior high school, or 9th and/or 10th grade levels.

History of Industrial Technical and Vocational Education

The history of vocational education has been well documented through the 1960s or early 1970s by the American Vocational Association (1986), Barlow (1967, 1976, 1990), and Bennett (1926, 1937). The following discussion is a summary of some of the conditions and events that occurred in the evolution of industrial technical education and vocational education in the United States.

Early Industrial Technical Education in the United States. The early history of industrial technical education closely parallels that of vocational education. Early technical education involved the transfer of knowledge and skills from the skilled artisan to the learner. Apprenticeship laws were passed in the Plymouth and Massachusetts Bay Colonies to provide poor children with the benefits of being placed in households that could provide better sustenance and education (Barlow, 1976; Walter, 1993). Apprentices were indentured to masters through contracts that provided for their training and physical needs in exchange for their labor. Prior to the Industrial Revolution, the apprenticeship program grew in the United States until the demand for skilled labor outgrew the available supply. Apprenticeship education, however, did not meet the needs in factories for mechanics, engineers, and the diversity of other skilled occupations required at that time (Barlow, 1976; Walter, 1993).

The expansion of the frontier in the new nation and the development of the factory system resulted in the formation of many different types of schools. They included asylums or farm schools, lyceums, and mechanics institutions with expanded curriculums to meet the needs of artists, farmers, and mechanics. Private charity, society of mechanics, and manual labor movements developed schools to prepare factory workers, tradespeople, and mechanics. The mechanic institutes provided their members with a knowledge of mechanical sciences. Gradually, they opened their doors to tuition paying students and expanded their curriculum to include more English, mathematics, classical studies, and practical science, so they could place more emphasis on the application of scientific principles in the workplace (Barlow, 1976 & 1990; Walter, 1993).

During the middle 1820s through the early 1860s, the United States became more industrial and urban. Extensive debate took place regarding the purposes of private and public education. Throughout this time period, the common school began to evolve as the primary means for providing education for the masses (Barlow, 1976; Walter, 1993).

The concept of the private academy was imported from Europe as the battle for public education was being won in the United States. The academies, in order to compete with public high schools for the same population, provided college bound, general preparation, and vocational training programs (Walter, 1993). The manual labor movement supported academies that required their students to learn basic knowledge and technical skills. These students usually worked in local businesses with the business paying the school for the services rendered. To counter the expansion of technical education in academies, many states required them to become more academic (Walter, 1993).

The passing of the Morrill Act in 1862 demonstrated that there was a need for technical education at the university level. This Act provided public land to establish colleges for the benefit of agriculture and the mechanical arts. It gave states the opportunity to establish land grant colleges as long as the state legislatures accepted the federal act within a given time period. The implementation of the Morrill Act set an example for a way to implement vocational education during the late 1800s and a means for preparing vocational education teachers (Barlow, 1976).

During the latter part of the 19th century, public education changed to provide more scientific theory and the means for applying that theory (Walter, 1993). The implementation of manual training in private schools caused public schools to change their curricula. Manual training activities were introduced at the college level to help applied mechanics students visualize solutions to problems. This approach culminated in the development of specific projects, which when built, resulted in students practicing with machines and tools. Graduates not only became familiar with visualization, but also with different manufacturing techniques (Barlow, 1976; Walter, 1993).

Calvin Woodward's success with manual training at the college level, and the implementation of a secondary level school curriculum that included mathematics, science, languages, drawing, and shopwork, were significant factors in the development of manual training in this country. Even though many graduates were employed in different trades, the major emphasis of the program was to provide general rather than specific skill development. Private manual training schools were built in many large cities and competed with existing public high schools. This competition resulted in some public high schools including manual training in their curriculum (Barlow, 1976; Walter, 1993).

The Evolution of Vocational Education. The manual training movement confirmed the idea that technical preparation could and/or should be taught in public schools. Walter (1993) noted that the "... spread of manual training signaled the beginning of a shift from the belief that the ideal high school curriculum was one devoted solely to college preparation, to one which also reflected the need to prepare students to a variety of career options requiring less than college-level preparation" (p. 6). The trade school movement evolved to meet specific needs. Basic elements of the curriculum were learning a trade, gaining industrial experience, and acquiring the general education needed to be successful in the trade. Trade schools were private, public, or operated by a company. Some of the first trade schools were the New York Trade School (*circa* 1881), the Hebrew Technical Institute (*circa* 1883), Williamson Free School of Mechanical Trade (*circa* 1891), industrial trade programs by R. Hoe Company (*circa* 1872), Baldwin Locomotive (*circa* 1901), and General Electric Company (*circa* 1902) (Barlow, 1976).

During the latter part of the 1800s and up through the 1970s, different programs that were related to or prepared students for employment or life skills evolved separately, and eventually became part of vocational education as it is known today. The passage of the Smith-Hughes Act in 1917 was the beginning of funding for vocational education. The passage of additional acts restructured and continued the funding of vocational education. They also provided funding for other fields, such as business, marketing, health, and vocational guidance, in order for them to become a part of vocational education.

As the 19th century drew to a close, the concept of preparing people for industry at the high school level was gaining momentum. The evolution of corporate, trade, and evening adult schools focused "... attention on the need for skilled industrial workers and the shortage of programs to prepare them" (Walter, 1993, p. 8). Industrial educators, who supported the preparation of skilled workers, organized on a national scale and established a subcommittee in November, 1906 called the National Society for the Promotion of Industrial Education (NSPIE). Industrial educators, who supported the view that the study of industry should become part of general education, founded industrial arts, which, today, has become known as technology education.

The NSPIE fight for the passage of the Smith-Hughes Act was joined by home economic and agricultural advocates. Domestic science evolved as the long-standing prejudice against educating women was eliminated. In the 1870s, cooking and household arts were expanded to include home furnishings, care of the sick, care of children, physiology, and domestic chemistry. More domestic science classes were taught in public schools as the result of the establishment of the National Household Economics Association, the Rumford Kitchen exhibit program providing information on food and nutrition by leading universities, and the founding of the Bureau of Home Economics. The process involved in defining home economics and convincing the public of the value of the field led to the establishment of the Home Economics Association in 1899 (Walter, 1993).

Agricultural courses were included in public schools prior to 1862. The passage of the Morrill Act in 1862, however, resulted in the elimination of these courses. Higher education institutions with programs designed to provide practical applications of science and technology in agriculture and industry were not well attended as had been expected. The advocates of agricultural education, therefore, expressed the need to return their programs to public education (Walter, 1993).

At the beginning of the 20th century, the Massachusetts Commonwealth, the National Association of Manufacturers (NAM), and the American Federation of Labor (AFL) generated their own plans to prepare people for agriculture, domestic, and industrial occupations. A compromise position paper was published in 1910 by the NAM, the AFL, and the National Education Association. Since the paper did not identify the best means for providing the type of education that was needed, the NSPIE assumed a leadership role in securing federal support for home economics, trade and industrial education, and agricultural education to become vocational education (Barlow, 1976; Walter, 1993).

The NSPIE had gained state support for industrial programs but, as in the past, only land grant colleges received federal support for education. Rural congressional representatives and senators supported the establishment of an agricultural extension service. The leaders of the NSPIE agreed to reduce their lobbying efforts for industrial programs until the Smith-

Lever Act was passed. Once enacted, it was understood that advocates of agricultural and home economics education would join efforts with the NSPIE to secure funding for industrial education. This compromise created the Commission on National Aid to Vocational Education in 1914. The passage of the Smith-Hughes Act in 1917 provided funds for vocational education, generated cooperation among the states to promote education in agriculture, home economics, and trades and industries, and provided the means for preparing teachers in vocational subjects (Barlow, 1976; Walter, 1993). States, in order to have access to federal funds, had to do the following: (a) form state boards and develop plans of action for implementing vocational education, and (b) allocate state funds to support vocational education.

A Federal Board of Vocational Education was appointed and it prepared a plan for developing working relationships with and policies for implementing vocational programs in different states. Over the years, the Board took on three major functions: (a) administering federal funds efficiently, (b) researching and studying the promotion and improvement of vocational education, and (c) assisting states in promoting and implementing vocational education (Barlow, 1967). The Board reported annually to Congress until the great depression in the 1930s. It later lost its independent status and its administrative function was transferred to the United States Department of the Interior. Even though all of these changes were occurring, Congress did not reduce funding for vocational education (Barlow, 1967). On October 10, 1933, the Federal Board of Vocational Education was transferred to the United States Office of Education. The Board served in an advisory capacity for over 12 years until it was abolished by President Harry S. Truman (Barlow, 1967).

During the time period 1929 to 1982, many acts were passed that provided direction for vocational education. The George-Reed Act of 1929 provided additional funding for home economics and agriculture and shifted the basis for calculating each state's allocation. The George-Elizey Act of 1934 replaced the expiring appropriations in the George-Reed Act and increased appropriations for vocational education. Total appropriations for vocational education were increased in the George-Dean Act of 1936 and funds allocated to agriculture, home economics, and trade and industry education were equalized. Distributive education was also included as a new area of vocational education and was funded at a reduced rate when compared to the other three areas (Barlow, 1976; Walter, 1993).

The American Vocational Association (AVA) was founded in 1926 when a national and regional association joined forces. The NSPIE became the National Society of Vocational Education (NSVE) in 1906. The Federal Board of Vocational Education planned many of its meetings in conjunction with the NSVE and in 1925, the Board worked with the NSVE to determine ways to create more uniformity among the existing state vocational education plans. At the same time, the NSVE considered joining forces with the Vocational Education Association of the Mid-West (VEAMW) to form an association to represent vocational education. The two groups had also talked with the American Home Economics Association and the National Vocational Guidance Association about joining forces, but to no avail. The NSVE and the VEAMW joined forces in 1926 to become the American Vocational Association.

Unity became the theme of the AVA as it set out to become the association to represent vocational education. One of its major missions was and continues to be increased federal support for vocational education. The AVA was one of the first associations to move to Washington, D.C., and still maintains its headquarters in suburban Virginia (American Vocational Association, 1986). The objectives of the AVA in 1926 were the following:

- To assume and maintain active national leadership in the promotion of Vocational Education.
- To render service to state and local communities in stabilizing and promoting Vocational Education.
- To provide a national open forum for the discussion of all questions involved in Vocational Education.
- To unite all the Vocational Education interests of the country through membership representative of the entire country. (American Vocational Association, 1986, p. 23)

During the depression, the value of various governmental offices, services, and programs were reviewed. In 1936, President Franklin D. Roosevelt created a national committee to study vocational education. The result of the study, known as the Russell Report (1938), noted "... the positive impact of federal support in expanding and improving vocational programming at the secondary level and in creating a more favorable attitude toward it in the minds of many educators" (Walter, 1993, p. 12). Serious concerns were expressed in the report that trade and industrial education was not having the influence on the economy that had been expected initially, vocational education should become more general and flexible, and vocational education should provide minimal guidance and placement services for students in the program and upon graduation. In 1946, the George-Barden Act was passed. It provided the states more flexibility in spending the $36 million appropriation and encouraged further development of vocational guidance (Walter, 1993).

The launching of Sputnik by the USSR in 1957 actualized the need for reform and demanded that American education provide mathematics, science, and technical training to keep pace in national defense and space exploration. The need for schools to offer more science, mathematics, and technical education to address the shortages of laboratory and technical personnel in science and engineering resulted in the passage of the National Defense Education Act (NDEA) in 1958. The NDEA raised the educational consciousness about the need for technical education in the United States and resulted in the inclusion of funding for technical education as part of the Vocational Education Act (VEA) of 1963 (Walter, 1993).

In the 1960s, the high rate of unemployment and the lack of appropriate training to meet the demands of a changing labor market prompted Congress to cut vocational funds by $2 million (these funds were later restored). During routine Congressional hearings, vocational education came under criticism for not meeting existing manpower needs that had come about as a result of the rapid technological changes of the 1950s. Additional concerns were expressed for not meeting the needs of the slow learner, handicapped, disadvantaged, and other related social problems, even though financial resources had not been provided to address these problems (Barlow, 1976; Walter, 1993).

In 1961, an advisory committee was established by President John F. Kennedy to review and evaluate the existing vocational acts and to make recommendations for the future of vocational education. An appointed panel of consultants presented their findings in 1963 in a report entitled *Education for a Changing World of Work*. The report's summary noted that vocational education must offer training opportunities to 21 million non-college graduates, update existing skilled workers, provide technical education beyond high school, expand the scope of vocational education to meet economic needs, and make educational opportunities available to all people. The panel went on to recommend that local-state-federal partnerships should increase support for vocational and technical education high school students, youth with special needs, post-secondary students preparing to enter the labor market, and unemployed youths and adults. Additional services recommended by the panel included implementing teacher and leadership training programs, providing basic educational materials and equipment for specific occupations, providing occupational and guidance service for all students, and encouraging, supporting, and coordinating research and development in vocational and technical education (Barlow, 1976). The Vocational Education Act of 1963 was passed, which resulted in allocating $400 million to vocational and technical education (Barlow, 1976; Walter, 1993).

The Vocational Education Act and Amendments of 1963, 1968, and 1972 provided mandates about needed adjustments in American education and confirmed the dedication of vocational educators to provide quality vocational education to a larger population (Barlow, 1976). The acts and amendments demonstrated a change in federal policy from simply supporting vocational education, to one of effecting change (Walter, 1993). An additional benefit was that they allowed other related programs to apply for funding for specific services to be rendered. The 1963 Act, for example, accomplished the following: (a) addressed the specific concerns previously noted above by the panel of consultants, (b) eliminated categorical funding restrictions established by the Smith-Hughes Act, (c) changed allocation formulas established by earlier acts so that federal funds could be transferred from one category to another in order to meet new labor market needs and could be "... distributed on the basis of state population and per capita income rather than rural versus urban population" (Walter, 1993, p. 14), and (d) mandated the creation of advisory councils to oversee the implementation of the Act's provisions. The 1968 Amendments reflected the following recommendations made by the National Advisory Council:

> ... reaffirmed the objectives of the 1963 act; emphasized post-secondary education; ... earmarked funds for persons with special needs (academic, social, economic, physical, and mental handicaps); reinforced the distinction between occupational and consumer home economics by labeling and funding non-occupational programs as Consumer and Homemaking Education; and broadened the definition of vocational education to include prevocational orientation, employability skills, job placement, and the academic education necessary for employment preparation. (Walter, 1993, p. 15)

Additional funds were made available to stimulate growth in vocational guidance and cooperative education, and to establish a national advisory board and state advisory boards to oversee the implementation of state plans (Walter, 1993).

The mission of vocational education was expanded in the 1972 amendments. Funding for industrial arts programs that contributed to the goals of vocational education was included, as well as an amendment that authorized a series of new grants for the preparation, counseling, and placement of vocational education programs at the elementary, secondary, and post-secondary levels. Title X of the Act stimulated the establishment or the expansion of community college occupational programs. This resulted in occupational program enrollments increasing from 13% in 1965 to almost 50% of the total student population by 1975 (Walter, 1993).

Changes were made in existing educational acts. The Educational Amendments of 1974 "... held particular significance for vocational education: (1) the Title I required that an individualized learning plan be developed for each educationally deprived child; (2) the creation of the Office of Career Education; and (3) the charging of the U.S. Commissioner of Education and the Secretary of Labor with the shared responsibilities of assessing the need for bilingual education in vocational education" (Walter, 1993, p. 16). The 1976 Education Amendments resulted in vocational education having to address concerns related to the following areas: (a) sex equity, (b) handicapped, disadvantaged, and limited-English-speaking students having access to programs and services, (c) improving planning and coordination of resources, and (d) objective evaluation of the effectiveness of vocational education (Walter, 1993).

In 1976, the National Institute of Education was given the charge to evaluate the extent to which vocational education was meeting federal education guidelines. Their findings, published in 1981, acknowledged that some success was being made in meeting sex equity guidelines, some progress was being made in state planning, and state plans had little effect on local programs. Their report concluded that "... (1) the vocational acts attempted to accomplish too much with too little money; (2) mismatches existed between the outcomes Congress desired and the means provided to achieve them; and (3) the influence of federal legislation was limited if states and local schools did not share the identified objectives" (Walter, 1993, p. 17).

Differences in viewpoints between the House and Senate resulted in a compromise in formulating and eventually passing the Carl D. Perkins Vocational Education Act of 1984. The House wanted the improvement, modernization, and expansion of vocational education programs while the Senate version placed more emphasis on the social aspects, with provisions to provide more and better services for special needs. The Perkins Act "... specified three primary objectives: (1) provide improved access and programs for special needs populations; (2) improve the quality of all vocational education programs; and (3) increase the economic impact of vocational education" (Walter, 1993, p. 17). The Act specified that 57% of the basic state grants be spent to meet the following specific needs: handicapped (10%), disadvantaged (22%), adult training (12%), single parents or homemakers (8.5%), elimination of sex equity (3.5%), and criminal offenders (1%). The Act also required the mainstreaming of disadvantaged and handicapped students, implementing sex equity programs, and implementing assessment plans (Walter, 1993).

In 1990, the 1984 Carl D. Perkins Act was amended to authorize the federal government to spend up to $125 million on technical preparation (tech prep) programs (Brustein, 1993). Funding of tech prep programs requires an articulation agreement between a secondary school and a post-secondary institution that, when a student successfully completes a program, culminates in a two-year certificate or associate degree. The articulated program must be in a field of engineering technology, applied science, industrial, practical arts or trade, agriculture, health, or business. The articulated program must include mathematics, science, and communications through a regular or an applied articulated academic program. The articulated four-year program must lead to employment placement (Brustein, 1993). State plans for vocational education were revised in order for states to receive funds for tech prep.

Principles of Vocational Education

The principles of vocational education have existed for many years and are used to evaluate ongoing practices and provide guidance for future action. The principles of vocational education are the following:

- Programs shall provide a realistic balance between vocational interests of individuals and needs of business, industry, and society.
- Programs shall allow individuals to enter, progress, and exit as their specific needs dictate.
- Programs that are realistic in terms of actual or anticipated occupational requirements shall be provided to all individuals who need and can profit from them.
- Programs shall provide options that will benefit individuals entering, upgrading, or retraining for employment.
- Programs shall provide for individuals' unique needs, experiences, and abilities.
- Programs shall offer direct value to society in relation to economic stability and the supply and demand of the labor force.
- Programs shall provide opportunities for individuals to discover and develop their vocational interests and abilities and to be assisted toward placement in the occupation for which they receive instruction.
- Programs shall develop work attitudes, saleable skills, and usable knowledge related to employment.
- Programs are based on a systematic assessment of social, economic, and employment needs. (Roberts, 1971, Chapter 20; Findlay, 1993, p. 27)

	Temporary			Non Bachelor Degree			Bachelor Degree			
	Y/N	Ind. Exp	Other	Y/N	Ind. Exp	Other	Y/N	Ind. Exp	Other	Other
Region 1										
Connecticut				Y	3	Y	Y			
Delaware				Y	6	Y	Y	2	Y	
Maine				Y	3-4	Y	Y	2	Y	
Maryland				Y	3-5	Y	Y	2	Y	
Massachusetts				Y	6	Y	Y	3		
Michigan	Y	2	Y				Y	2		After 3 years teaching exp, 18 credit hours or master's degree
New Hampshire				Y	5	Y				
New Jersey				Y	4	Y				
New York				Y	2-4	Y				
Ohio	Y	Y	2-5				Y	2	Y	
Pennsylvania	Y	0	Y	Y	0-2	Y				Complete professional development plan every 5 years
Rhode Island	Y	Exp needed	Y				Y	Exp needed		Permanent: Master's or 36 hours of approved study
Vermont				Y	6	Y	Y	3		
Region 2										
Alabama							Y	Internship	Y	or Master's degree with 12 hours in teaching field
Florida				Y	6	Y	Y			
Georgia				Y	2	Y	Y		Y	
Kentucky	Y	4	Y				Y	2000 hrs	Y	
North Carolina				Y	4	Y				
South Carolina				Y	4-8	Y	Y	1		
Tennessee				Y	5	Y	Y	Y		
Virginia				Y	2	Y	Y	2		Technical Professional Certification (5-year renewable)
West Virginia	Y	4					Y	3	Y	
Region 3										
Illinois	Y	4	Y	Y	1	Y	Y			
Indiana				Y	2-3	Y				
Iowa				Y	Y	Y	Y			
Minnesota				Y	Y	Y				
Missouri							Y	3		
Wisconsin				Y	?	Y				5 year certificate-14 hrs in specific education courses or in-service activity

	Temporary			Non Bachelor Degree			Bachelor Degree			
	Y/N	Ind. Exp	Other	Y/N	Ind. Exp	Other	Y/N	Ind. Exp	Other	Other
Region 4										
Arkansas				Y	2	Y				
Louisiana				Y	Y	Y				
Mississippi				Y	2	Y	Y		Y	
New Mexico				Y	2-5	Y	Y	2		
Oklahoma							Y	2-3		
Texas							Y	3	Y	
Region 5										
Alaska				Y	2-4					
Arizona				Y	3	Y	Y	1		
California				Y	5	Y				
Colorado				Y	5	Y	Y	2		
Hawaii				Y	2	Y	Y			
Idaho				Y	8	Y	Y	3		
Kansas							Y	2	Y	
Montana				Y	5	Y	Y	1		
Nebraska							Y		Y	
Nevada				Y	5	Y	Y	2	Y	
North Dakota				Y	4	Y				
Oregon				Y	2-3	Y	Y	2	Y	
South Dakota							Y	Y		
Utah				Y	6	Y	Y			
Washington				Y	Y	Y	Y	Y	Y	
Wyoming							Y	2		

Note: Contact the state department of education for more information on an individual state's certification requirements.

Figure 2-3: Summary of state minimum requirements for trade and industrial education certification.

Vocational Trade and Industrial Education Certification

Vocational teacher education certification and curriculum components are determined by the vocational area of study and each state's vocational certification requirements. Certification requirements determine the nature and components of vocational trade and industrial teacher education certification in a given state. Generally, certification is based upon some combination of occupational competency and teacher education preparation. As one requirement is increased, generally, the other requirement is decreased. Most states require work experience and/or a baccalaureate degree in teacher education to become certified.

A study conducted in 1993 for the AVA determined each state's certification requirements to teach trade and industrial education at the secondary level. These requirements are shown in Figure 2–3. Thirteen states require a baccalaureate degree with experience and/or courses in specific technical fields in order to become certified in trade and industrial education. These states are Alabama, Kansas, Kentucky, Michigan, Missouri, Nebraska, Ohio, Oklahoma, Rhode Island, South Dakota, West Virginia, Texas, and Wyoming. Michigan and Rhode Island require additional semester hours or a master's degree for permanent certification. Non-baccalaureate degree requirements exist as a minimum for the 13 states of Arkansas, Alaska, California, Indiana, Louisiana, Minnesota, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Pennsylvania, and Wisconsin. Certification in the remaining 24 states can be earned with a non-baccalaureate program or a baccalaureate degree. About half of the states "...require prospective vocational teachers to pass occupational competency tests before they are certified..." (American Vocational Association, 1993, p. 35). In 1989, the states of Alabama, Arkansas, Colorado, Georgia, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Mississippi, North Dakota, Oklahoma, Pennsylvania, Rhode Island, Utah, Vermont, Virginia, and West Virginia used the National Occupational Competency Testing Institute exams for "... initial certification, for recertification within the first year or for pre-service teachers lacking work experience" (American Vocational Association, 1939. p. 35). Seven states offer temporary certification for a predetermined time period. In cases of severe shortages, the time period may be extended (American Vocational Association, 1993).

Vocational Trade and Industrial Teacher Education Curriculum Components

A baccalaureate degree program with a technical concentration in a trade and industrial education specialty consists of a general education component of 30–50 semester hours, a professional education component of 16–27 semester hours, and a technical component containing 32–45 semester hours. In some states, in addition to having an earned baccalaureate degree or a baccalaureate degree in education with a technical specialization, graduates are required to have in-depth technical knowledge as demonstrated by completed course work, passing a technical competency exam, and/or industrial experience in the trade or industrial education field to be taught. At one end of the continuum, some trade and industrial education baccalaureate degree programs require a given number of semester hours in the technical field to be taught. While at the other end of the continuum, a baccalaureate degree, plus three years of industrial experience in or related to the teaching technical field, are required (American Vocational Association, 1993).

Administering Vocational Trade and Industrial Teacher Education Programs

Trade and industrial education teacher education program organizational structures are similar to those found for technology teacher education programs. They are usually housed in colleges of education, professional studies, technology, applied science, applied science and technology, or agricultural science and technology. Many vocational trade and industrial teacher education programs are in a department with technology education, industrial training, or a non-teacher education program, such as agriculture, industrial technology, or engineering technology. It is common for teaching and non-teaching programs to share technical faculty, laboratory facilities, and teacher education curriculum.

Employment Opportunities in Vocational Education

Teaching positions in trade and industrial education exist in comprehensive vocational high school programs and in post-secondary careers, technical institutes, community colleges, and in private industrial training. Industrial experience, degree of expertise, teaching experience, and availability of specific trade and industrial education positions determine the job market and the teaching salary. Teachers generally have the opportunity to earn tenure. Other positions for teachers are those of program coordinator, department head, district supervisor, and state supervisor.

Advanced Study and Associations

Teachers with baccalaureate degrees can earn master's or doctoral degrees in vocational education or in a related educational field. In some states, the master's degree may be required for permanent certification. Advanced degrees may qualify individuals for program management positions, positions in curriculum development, teacher development, vocational counseling, and consulting.

The AVA, as a professional association, represents vocational education. The association consists of divisions that represent different occupational fields: agriculture, business education, health occupations, home economics, marketing education, technical education, technology education, and trade and industrial education. The National Association of Industrial and Technical Teacher Education (NAITTE) was originally formed to represent industrial teacher educators, but today it includes teacher educators in technology education, trade and industrial education, technical education, and industrial and military training. One of the major reasons NAITTE was founded was because most of its members favored college-based trade and industrial teacher training programs (Evans, 1988). At the local, state, and national levels, trade and industrial education students have the opportunity to demonstrate their technical knowledge and leadership abilities through the Vocational Industrial Clubs of America (VICA). As an integral part of the trade and industrial programs, VICA activities enhance classroom instruction (North Carolina Department of Public Instruction, 1992).

Scope and Sequence of Trade and Industrial Education

Each state develops vocational education plans to meet federal, state, regional, and local needs and they usually include a trade and industrial education curriculum. Since each plan varies by state, the North Carolina trade and industrial education curriculum will be reviewed as a typical example of a state plan.

The North Carolina State Department of Public Instruction's definition of trade and industrial education will be used since there is no universal definition. Trade and industrial education has been described as "... a secondary program designed to prepare students for careers in industry and the trade occupations through a sequence of learning experiences. Instructional units are provided in the use of layout, designing, producing, processing, assembling, testing, maintaining, and servicing of industrial, commercial, and residential goods and products, as well as public services" (North Carolina Department of Public Instruction, 1992, p. 65).

The major outcomes of North Carolina's trade and industrial education plan are the following:

1. Develop basic manipulative and technological skills relative to indus-

trial occupations through a combination of simulated shop and laboratory experiences or on-the-job training experiences.

2. Provide technical information (principles and theory) with emphasis on application of mathematics, design, economics, science, and computer skills pertinent to employment and success in an industrial occupation.

3. Provide instruction in such areas as human relations, safety and health, the development of positive work habits, the importance of learning and maintaining employability skills, and encouraging and understanding of all socioeconomic factors essential to [for] obtaining employment and achieving success in an industrial occupation.

4. Develop the skills needed to exercise and follow effective leadership in fulfilling occupational, social, and civic responsibilities. (North Carolina Department of Public Instruction, 1992, p. 65)

The scope and sequence of North Carolina's trade and industrial education plan are as follows:

> The total scope and sequence of Trade and Industrial Education includes varied program offerings for students in grades 9 though 12. Students may enter and progress through one of several program sequences in order to achieve their major occupational objective. Students are encouraged to select courses from other course offerings to complement their Trade and Industrial Education courses based upon on each student's occupational objective. (North Carolina Department of Public Instruction, 1992, p. 65)

Courses in technology education or trade and industrial education may be used at the 9th and 10th grades. Qualified technology education courses are Fundamentals of Technology, Manufacturing Systems, Communications Systems, Structural Systems, and Transportation Systems. A qualified trade and industrial education course, which may be used at the 9th and 10th grades, is Introduction to Trade and Industrial Education (North Carolina Department of Public Instruction, 1992).

The program is designed to prepare students for initial employment and for advancement in a wide range of related trade and industrial occupations. The major industrial areas of the trade and industrial education program are construction, manufacturing, transportation, communication, and public/private industrial services as shown in Figure 2–4 (North Carolina Department of Public Instruction, 1992). Each of the industrial areas include in-depth courses in related trades. A balanced program of classroom study

Construction	Transportation
Carpentry Electrical Trades Masonry Air Conditioning and Refrigeration	Auto Body Repair Automotive Technology
Manufacturing	**Communication**
Electronics Furniture/Cabinet Making Industrial Maintenance Metals Manufacturing	Graphic Communications Technical Drafting
	Public and Private Industry Services
	Cosmetology Industrial Cooperative Training

Figure 2-4: North Carolina trade and industrial education curriculum clusters (NC Department of Public Instruction, 1992, p. 65).

and practical work experience produces competent workers who can manage resources, work cooperatively, organize and use information, understand complex systems, and apply appropriate technology. Cooperative education experiences are available through the industrial cooperative education component of the trade and industrial education program (North Carolina Department of Public Instruction, 1992).

INDUSTRIAL TECHNOLOGY

Baccalaureate degree programs in industrial technology prepare people for employment as technical managers in industry, business, and government, with the vast majority of the graduates employed in industry. These broad based technical programs consist of an overview of a technical area of study, the application of technical knowledge, technical problem solving, and technical management courses. The programs prepare graduates to supervise and/or manage complex technical systems which include both human and technical resources.

Definition of Industrial Technology

At the associate and baccalaureate levels, industrial technology is defined as "... a field of study designed to prepare technical and/or technical management-oriented professionals for employment in business, industry, and government" (National Association of Industrial Technology, 1994, p. 1). The degree programs and professionals who pursue careers in industrial technology will typically be involved in the following:

- Application of theories, concepts, and principles found in the humanities and the social and behavioral sciences, including a thorough grounding in communication skills.
- Understanding of the theories and the ability to apply the principles and concepts of mathematics and science and the application of computer fundamentals.
- Application of concepts derived from, and current skills developed in, a variety of technical and related disciplines which may include, but are not limited to, materials and production processes, industrial management and human relations, marketing, communications, electronics, and graphics.
- Completion of a field of specialization, for example, electronic data processing, computer aided design, computer integrated manufacturing, manufacturing, construction, energy, polymers, printing, safety, or transportation. (National Association of Industrial Technology, 1994, p. 1)

The National Association of Industrial Technology (NAIT) accreditation guidelines denote that associate degree programs prepare individuals for technical professions whereas baccalaureate programs prepare graduates for technical management positions.

> Four-year programs accredited in colleges and universities shall lead to the baccalaureate degree and shall be designed to prepare management-oriented technical professionals. Programs will include at least the junior and senior years of a baccalaureate program, with appropriate lower division work from the four-year institution or from associated community colleges and technical institutes. Industrial Technology curricula which combine liberal education with professional-level technical management may be evaluated for accreditation at the baccalaureate degree level. Programs considered must prepare students for technical management positions in areas such as industrial planning, production, supply, product market research, and technical sales. (National Association of Industrial Technology, 1994, p. 2)

History of Industrial Technology Education

Industrial technology evolved from industrial arts teacher education, vocational trade and industrial teacher education, and mechanics and technical institute programs. The need for technical people in industry with a broad technical background and advanced degrees stimulated the growth of industrial technology. The major mission of the program today is to prepare technical managers for industry.

The industrial, economic, social, and cultural environment had an effect on higher education from 1890 through 1950. Keith and Talbott (1991) identified major changes including

- agricultural and mechanical arts colleges and universities expanding their technical, science, and liberal arts offerings,
- colleges and universities revising their two-year and three-year curricula to meet the standards expected of four-year baccalaureate degree programs,
- the change from the use of normal schools to teacher education colleges for the preparation of teachers,
- an increased demand for students to earn a higher education degree,
- the development of community colleges, and
- the government providing incentives for military personnel to earn undergraduate degrees. (p. 2.1)

Changes that had an effect on industrial technology during the late 1940s and 1950s were "... (a) the demand for an educated workforce, (b) engineering programs becoming more theory oriented, and (c) higher education being more accessible to the populace" (Keith & Talbott, 1991, p. 2.1).

Industrial technology evolved from two different sources: (a) the mechanic arts programs and the two-year technical institutes, and (b) programs that prepared industrial arts and vocational trade and industrial education teachers (Keith & Talbott, 1991). The Russian instructional system joined with the mechanic arts movement to produce programs of engineering training and the preparation of skilled mechanics (Bennett, 1937). Private charity schools, known as technical institutes, developed in the late 1800s and the early 1900s to meet the need for highly skilled mechanics (Barlow, 1967). The more famous institutes were sponsored by well-known societies of mechanics or people who supported technical education. The development of technical skills became part of the formalized preparation of engineers in many universities in the United States through the late 1960s and early 1970s. As engineering became more theoretical, the remaining mechanic arts or practical arts laboratory courses were deleted from engineering programs, and some of the courses became a part of engineering technology or industrial technology programs (Keith & Talbott, 1991).

Utah State University, West Virginia State College, and Bradley University were the first educational institutions that developed industrial-based programs to prepare graduates for industry prior to 1950. A complete listing of institutions offerings programs prior to 1950 is shown in Figure 2–5. The most famous technical institute known for the development of an industrial option was Bradley University, which was previously known as Bradley Institute and Bradley Polytechnic Institute. Bradley University was a recognized leader in manual arts and industrial education. It changed its emphasis in the 1930s and 1940s and became known for preparing people for industry (Keith & Talbott, 1991).

The second source of industrial technology programs was non-teaching degree options in vocational trade and industrial education and industrial arts teacher education programs. This movement gained momentum during the 1950s through the 1970s. Some of the first higher education institutions to offer industry options were Southern Illinois University, Pittsburgh State University, Colorado State University, and Montana State University (Keith & Talbott, 1991). The first teacher education program to use the term industrial technology was Kent State University. This four-year baccalaureate program was approved in May, 1950 and first appeared in the

Year	Educational Institution	Type of Program
1912*	Utah State University	Mechanic Arts
1932**	West Virginia State College	
1939***	Bradley University	Manual Arts; Technical Institute
1944	Southern Illinois University	Industrial Education
1945	Pittsburgh State University-Kansas	Mechanic Arts; Industrial and Vocational Education
1946	Colorado State University	Industrial Arts
1947	Arizona State University	Industrial Arts
1948	Montana State University	Industrial Arts
1949	Alabama A&M University	Industrial Arts

*The first industrial technology program.
**Date has not been confirmed.
***Generally quoted as the first industrial technology program. It was one of the most widely recognized industrial technology programs before 1950 because of the stature of the people that were involved in the program.

Figure 2-5: Educational institutions offering programs that prepared graduates for industry prior to 1950 (Keith and Talbott, 1991, p. 2.2).

university's 1950–51 catalog. Several preliminary programs were started at Kent State University prior to 1950, but they lasted only a few years. These programs included factory management, economics-industrial arts, and pre-engineering (Keith & Talbott, 1991). The industrial technology baccalaureate programs that evolved through 1965 were classified as being technical-specific or technical-general with a management orientation (Keith & Talbott, 1991). The idea of a third orientation, engineering technology, was introduced, but it was not supported by the University (Keith & Talbott, 1991). The use of the term industrial technology, as the name of a program to prepare technical or technical management personnel, marked the beginning of an era of rapid growth in programs (Keith & Talbott, 1991). "Industrial technology grew as the result of industry's demand for employees who could (a) understand and implement industrial processes and procedures, and (b) work with and supervise or manage people" (Keith & Talbott, 1991, p. 3.1).

Since the 1950s, proposed industrial technology baccalaureate degree programs were carefully scrutinized by curriculum committees and liberal arts educators. The success of the approval process was dependent upon ". . . the economic, social, and cultural factors; the size and goals of the institution; and the political environment within the college or university" (Keith & Talbott, 1991, p. 3.2). Seventy out of 209 institutions listed in the 1958 *Industrial Teacher Education Directory* indicated they had industry options as part of their industrial education programs or as separate degree programs. The most common term used to label the options or programs was industrial technology (Keith & Talbott, 1991).

The primary emphasis of the curriculum was either technical, general, or engineering technology. Over time, the general or technical management emphasis evolved to become industrial technology, as it is identified by the National Association of Industrial Technology (National Association of Industrial Technology, 1994). In 1961, Weber completed a study of industrial arts and technical institute curricula which had been accredited by the Engineers' Council for Professional Development (ECPD). He concluded that industrial technology programs evolved out of industrial arts and vocational trade and industrial teacher education programs and were developed so students would gain an insight into the production of goods and knowledge about industrial management and distribution (Keith & Talbott, 1991). The industrial technology curriculum was noted as being general in nature with a management orientation, whereas the technical institute curriculum was engineering-based. The conclusions of a study conducted by Dobson (1962) were similar to those derived by Weber (1961), except that trade and industrial education programs were identified as being more technical-specific. Since Dobson supported technically-based programs, he recommended that four year industrial technology programs be built on junior college technical-specific programs (Keith & Talbott, 1991).

Other curriculum studies completed by Barnhart (1963) and Hauer (1963a, 1963b, 1963c) included the study of engineering technology programs. Due to the wide variations among the programs surveyed, Barnhart could only classify industrial technology programs either as general or specialized, which meant technical-specific. Hauer's findings supported those of Barnhart in that there were general and technical-specific programs. He caused confusion within the industrial technology and engineering professions when he referred to the management-oriented programs as engineering technology and the technical-specific programs as what are known today as technician programs. Hauer noted that both of these programs prepared semi-professional graduates. Other surveys concluded that the technical management programs prepared professional graduates who had a different orientation from engineering technology or engineering (Keith & Talbott, 1991).

In 1964, Herbert H. Wheaton, Dean Emeritus of the School of Arts and Science at Fresno State College and a registered engineer, conducted a national study of industrial technology programs. One of Wheaton's program classifications was vocational trade and industrial or technical-specific. He noted that programs in this classification evolved from mechanic arts, technical institutes, or trade and industrial teacher education programs. Wheaton's second classification was engineering technology as programs in this classification evolved from technical-specific mechanic arts programs that continued to emphasize engineering. Wheaton identified a third type, labeled general, that "... prepared graduates for the operating, sales, distribution, supervision, and management activities of industry" (Keith & Talbott, 1991, p. 4.11). The general industrial technology classification was found to be the most common, had evolved out of industrial arts, was administered by industrial arts, and was housed in industrial arts departments at most universities (Keith & Talbott, 1991). Wheaton indicated that the better industrial technology programs were broad in scope, did not offer a variety of options, and usually included business or management courses. Keith and Talbott (1991) stated the following:

> An interesting characteristic of the better programs in the general industrial technology field is that they do not offer a variety of options. These curricula are intended to be broad and fundamental in character, not training for specified areas of industry, and therefore do not lend themselves to subdivision into several course sequences. The only area in which an optional division sometimes appears is that of the

> business courses, where the program is at times divided into a management option and a sales option. (p. 4.13)

The general classification has evolved to become the main emphasis for industrial technology today (National Association of Industrial Technology, 1994).

Keith and Talbott (1991) indicated that Wheaton, upon completing his national study, offered some general observations about industrial technology. They were

- industrial technology administrators experienced difficulty in hiring and retaining competent industrial technology faculty,
- industrial technology faculty should have industrial experience,
- successful industrial technology programs had faculty that were constantly in contact with industries in their area,
- industrial technology programs were classified as being four-year vocational-technical, engineering technology, or general,
- industrial technology programs were providing the type of industrial personnel that were needed by industry,
- small colleges could not provide differential faculty for teacher education programs and an industrial technology program,
- the better general industrial technology programs do not offer a variety of options, and
- administrators of programs did not support a movement to form an accrediting agency for industrial technology. (p. 4.15)

In 1967, the National Association of Industrial Technology (NAIT) was founded indicating that industrial technology was coming of age as a profession. "The expectation of the founders was that NAIT could provide direction by formulating a philosophy, identifying objectives, developing criteria for accreditation, serving as an accrediting agency, providing data, and encouraging research" (Keith & Talbott, 1991, p. 1.1).

The NAIT was founded in October, 1967 at the third conference on industrial technology. The first conference, which was held at Kent State University, was organized in 1965 by Charles W. Keith, who is recognized as the founder of the NAIT. The first conference, which included representatives from 28 colleges in 20 states and 10 industries, provided the opportunity for participants to attempt to resolve common problems, explored the possibility for the accreditation of industrial technology programs, reviewed the opportunities of program graduates, and identified general curriculum patterns (Keith, 1986; Keith & Talbott, 1991).

The second conference was also held at Kent State University and "... had as its main thrust the identification of industry's needs, industrial technology curricular content, and potential accreditation standards and guidelines" (Keith, 1986, p. 5). Frank Dickey of the National Commission on Accrediting was the keynote speaker. He reviewed the history, role, and the purpose of accreditation in higher education. At the end of the second conference, a group of attendees initiated a draft of a constitution and bylaws, which was approved at the third conference hosted by Southwest Missouri State University (Keith, 1986). Charles W. Keith became the first president of the NAIT. The primary mission and objectives of the NAIT were established and five task forces were formed. The task forces were concerned with program standards and curriculum guides, coordinated research, industrial technology program trends and recent developments, faculty development and updating, and membership services (Keith and Talbott, 1991). Since 1967, the NAIT has held annual conventions throughout the United States.

The existing NAIT accreditation procedures and standards evolved from work initiated by Charles W. Keith, along with the standards and curriculum guides task force formed in 1967. Keith, in his 1964 dissertation, identified the following criteria for evaluating industrial technology programs and faculty:

- The catalog should reflect the purposes of the program.
- Ideally, the teaching staff should have had two to five years of industrial experience, 15 to 30 semester hours [of] professional preparation, 18 to 40 semester hours in special allied areas, and at least a Master's Degree.
- Proficiency in teaching is essential and important.
- Writing for publication is important.
- The program should consist of a sequence of respective areas or disciplines.
- The scholastic level of students in the program should be equal to or above that of other programs of the school.
- Graduates of the program should be qualified for employment in more than one type of industry.
- The program should be accepted and actively supported by the administration of the school.

- Areas and disciplines included in the program of study should contribute toward the purposes established for the program.
- Selection practices should be such that only students who can successfully complete the program would be admitted.
- Enrollment in the program should be directly related to the needs of industry.
- Staff load should permit for the maximum contribution of each staff member.
- The physical plant should provide sufficient space and appropriate up-to-date equipment to meet the requirements of the program.
- Fiscal allocation should be sufficient to support the program.
- An advisory committee composed of employers, graduates of the program, parents, and educators should participate in the development and operation of the program.
- Staff members should be actively identified with professional, educational, and industrial organizations. (Keith & Talbott, 1991, pp. 4.15–4.16)

In 1968, the NAIT membership approved a plan of action for establishing accreditation guidelines. Plans were formulated to submit a proposal to the National Commission on Accrediting (NCA) for the NAIT to become the recognized accrediting agency for industrial technology programs. The NAIT Standards and Accreditation Committee did not honor requests by the National Association of Trade and Technical Schools and the National Association of Specialized Colleges to become the accreditation agency, because both associations represented two-year programs. A decision was also made not to join the Engineers' Council for Professional Development (ECPD) since many industrial technology programs were management oriented. The accreditation proposal was not forwarded to the NCA until 1969, since the membership had difficulty in approving a definition of industrial technology (Keith & Talbott, 1991). Action on the application was deferred by the NCA with the suggestion that "... NAIT should further study current practices, curricula, industrial needs, ways in which the programs differed from engineering technology, and the success of graduates" (Keith & Talbott, 1991, p. 5.9).

The NAIT's request to accredit industrial technology programs was given a mixed reading by the engineering profession. Robert E. Vivian, Dean of Engineering at the University of Southern California, noted that industrial technology programs were in a "gray area" that existed between engineering and industrial arts and they needed to be controlled. He suggested that such interdisciplinary programs be administered by faculty with the highest level of technical knowledge, or the engineering division. Second, as engineering technology was gaining status within the engineering profession, Max S. Peters stated in *The Role of Technological and Technician Training* that engineering technology programs should not be allowed to develop in close relationship with engineering. He noted that a two-year program was sufficient (Keith & Talbott, 1991). A third position expressed by H. E. McCallick in a report on four-year engineering technology programs was that industrial technology programs should be accredited by the ECPD. He noted that engineering technology was being squeezed from below by two-year vocational associate degree programs and was being out-flanked by four-year technology programs. McCallick felt that industrial technology programs were sufficiently similar that they could be converted to engineering technology (Keith & Talbott, 1991).

The results of a study published in 1970, known as the "Banister Report," were used by the American Society for Engineering Education (ASEE) and the ECPD to identify unique differences between industrial technology and engineering technology. The findings provided the impetus for the NAIT to become the accreditation agency for industrial technology (American Society for Engineering Education, 1972; California State University and Colleges, 1970, 1977). The major differences identified by the ASEE (1972) were principle thrusts, faculty differentiation, and types of laboratories. The ECPD identified engineering technology's major thrust as the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities. Industrial technology's major emphasis was on assisting and directing the development program, the flow of production, the distribution of the product, and other facets of general management. These differences were described by the ASEE as follows:

> The key phrases for industrial technology education, according to the California State Colleges Report, are "occupying the mid-ground between engineering and business administration" and "emphasizing the applied aspects of industrial processes and personnel leadership." These objectives are sufficiently removed from "in support of engineering activities" to make necessary different curricular emphases in industrial technology from those of engineering technology. (American Society for Engineering Education, 1972, p. 22)

Using two different continuums, the ASEE noted the differences between engineering technology and industrial technology educational and employment goals as shown in Figure 2–6. The counterflow arrows in the diagrams illustrate increased emphasis on mathematics and science, and conceptual activity and theory. A model curricula analysis indicates that industrial technology includes a 50% math-science-technical content base with the other 50% being a non-science content base, which includes management. Engineering technology includes a 70% math-science-technical content base, which has an emphasis on a related engineering technical specialty. These differences resulted in the ASEE concluding that the differences between the two fields of study warranted different accreditation criteria (American Society for Engineering Education, 1972). In addition, other major differences identified were the background of the faculty and types of educational laboratories used in the programs. Engineering technology faculty with professorial rank above instructor held master and doctorate degrees with most of the doctorates being in engineering. Most industrial technology faculty held undergraduate degrees in technical teacher education or in related fields with industrial experience and advanced degrees in education. Engineering technology laboratories were noted for having a strong orientation towards experimentation and research, whereas industrial technology laboratories emphasized industrial processes (American Society for Engineering Education, 1972).

The ASEE report resulted in the NAIT taking the position that there was a demonstrated need for both the NAIT and the ECPD accreditation programs. The position was expressed as follows: "... for NAIT to attempt to accredit engineering technology programs would be just as undesirable and illogical as for ECPD to attempt to accredit industrial technology programs" (Keith & Talbott, 1991, p. 5.9). Prior to the NAIT resubmitting their application to the NCA in 1973, they educated the NCA board members and staff about the role and purpose of industrial technology, requested institutional administrators to write letters of support to the NCA, and completed a pilot evaluation of an industrial technology program to validate the NAIT's accreditation standards and procedures.

In 1973, the NCA approved the NAIT as the accrediting agency for industrial technology programs with the stipulation that the NAIT improve its appeals process and broaden the membership of the accreditation agency (Keith & Talbott, 1991). The NCA, meanwhile, was taken over by the Council of Post-Secondary Accreditation (COPA). In 1982, the NAIT withdrew from the COPA since the COPA had changed the financial requirements for accrediting agencies. The NAIT did not have the financial resources to support a national office and a full-time executive director. In 1989, the NAIT received approval from the United States Department of Education (USDE) to be the accrediting agency for industrial technology programs (Keith & Talbott, 1991). An extensive revision of the accreditation standards took place in 1990 with minor revisions of the standards and the

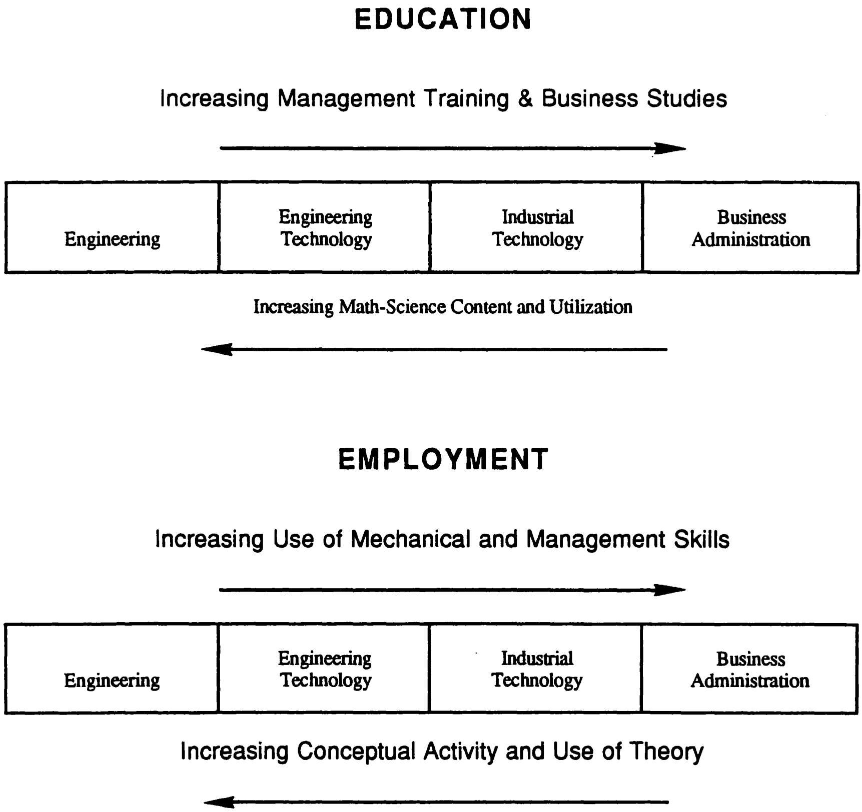

Figure 2-6: Interface of engineering technology with engineering and with industrial technology (ASEE, 1972, p. 23).

accreditation procedures in 1994. As of January, 1994, a total of 78 programs, or 152 programs and options in 39 different baccalaureate institutions, have been accredited by the NAIT. At the same time, a total of nine programs, or 18 programs and options, have been accredited in four different associate degree level institutions.

Other recent major NAIT undertakings have included sponsoring research projects, publishing of annual directories for two-year and four-year industrial technology programs, publishing of *The Journal of Industrial Technology* which has been issued quarterly since 1984, and developing and implementing post-secondary industrial technology two-year accreditation standards. The NAIT has also implemented its new divisions of industry, community college and technical institute (CCTI), student, and university to provide increased service and involvement for all areas of industrial technology. In 1991, the NAIT implemented a certification program for graduates of accredited programs. An exam was implemented in 1994 for industrial technology graduates from non-accredited programs to become certified. The senior certification level denotes that industrial technology graduates continue to professionally update themselves.

In 1993, a needs assessment of the NAIT activities was completed to reevaluate the definition of industrial technology, curriculum matrix and structure, accreditation and certification programs, and products and services provided by the NAIT. A survey was sent to 57 individuals who had served on the NAIT Executive Board, committee chairpersons that served from 1988 to 1993, and department heads or chairpersons of the NAIT accredited programs. A total of 42 usable responses were returned providing a 74% return rate. The survey consisted of closed-ended and open-ended questions (Miller & Rudisill, 1994). The response to the survey was very positive. Seventy-nine percent of the respondents indicated that the present definition was appropriate for guiding the NAIT into the 21st century. Written responses included broadening the definition to include pre-service and in-service activities and focusing the definition more on manufacturing and related areas, such as technical management and leadership, rather than management. There was overwhelming support (86–91% per division) for maintaining the university, industry, community college and technical institute, and student divisions with specific comments related to improving division operations. There also was overwhelming support (93%) for the NAIT's accreditation program, along with the recommendation to increase the number of accredited programs. Written suggestions for improving existing policies and procedures consisted of increasing the specificity of the standards, reviewing the standards for associate degree programs, increasing the variety of visiting team assignments, reducing the annual fees, involving more industry division members, increasing emphasis on faculty development, creating a national database, increasing consistency in the interpretation of the standards, and requiring training and certification of team members (Miller & Rudisill, 1994).

The NAIT certification program, which is relatively new, was addressed in the survey and 74% indicated their support for the program. Seventy-one percent of the respondents were supportive of automatically certifying faculty and graduates of the NAIT accredited programs. There was very strong support (98%) to keep the conference registration at its present level ($75 preregistration fee). In addition, 76% of the respondents supported continuing the publication, *The Journal of Industrial Technology*. Seventy-nine percent felt the Journal should continue to be published quarterly. Finally, there was mixed reaction to the idea of raising membership dues every two or three years (48%) versus every five to six years (41%) (Miller & Rudisill, 1994).

Respondents were asked to list goals for the NAIT in the next five years. Open-ended responses were categorized as follows:

- Increase professional membership (17 respondents).
- Promote NAIT accreditation (16 respondents).
- Disseminate information (14 respondents).
- Promote NAIT certification (12 respondents).
- Develop a core curriculum (7 respondents).
- Market NAIT and industrial technology (7 respondents). (Miller & Rudisill, 1994, pp. 9–10)

Other suggestions made were to improve organizational leadership (3 respondents), refine definitions (3 respondents), and increase the financial base (3 respondents). The authors concluded that the respondents were very supportive of the NAIT's activities and suggested some specific goals for the NAIT to accomplish by 1998 (Miller & Rudisill, 1994).

Goals for the Industrial Technology Profession

The NAIT has become the recognized national association for the industrial technology profession. The goals of the NAIT are the following:

a. To promote the establishment of curricula of Industrial Technology.

b. To promote the establishment and maintenance of curricular standards designed to serve the best interests of industry and the profession.

c. To provide opportunities for the study and discussion of all questions, issues, and problems related to curricula of Industrial Technology.

d. To promote and sustain worthwhile research endeavors related to curricula of Industrial Technology.

e. To provide opportunities for collecting, developing, and disseminating information concerning Industrial Technology education among its members, industrial personnel, fellow educators, administrators, counselors, students, and laymen.

f. To promote the goals and interests of the Association by cooperating with other national, regional, and local special interest organizations having related interests and goals.

g. To develop and maintain a common understanding among its members, industrial personnel, fellow educators, and the general public of the unique and essential role of Industrial Technology education as a function of the total public education system.

h. To provide through an accreditation process for recognition of the attainment of appropriate standards for Industrial Technology programs (National Association of Industrial Technology, 1988, pp. 3–4).

i. To promote the establishment and maintenance of less than baccalaureate level curricula in Industrial Technology (National Association of Industrial Technology, 1988, p. 12).

j. To promote the establishment and maintenance of appropriate personnel classifications within business and industry for associate degree level programs in Industrial Technology (National Association of Industrial Technology, 1988, pp. 12 & 19).

k. To promote the continuing professional development of Industrial Technology and other related personnel in business and industry (National Association of Industrial Technology, 1988, p. 19).

l. To promote the development of leadership capabilities of students enrolled in Industrial Technology programs (National Association of Industrial Technology, 1988, p. 27).

m. To promote the establishment and maintenance of student chapters within post-secondary level programs in Industrial Technology (National Association of Industrial Technology, 1988, p. 27).

Another goal of the NAIT has been to provide a certification process for the recognition of graduates and faculty of accredited industrial technology programs and for them to continue to update themselves professionally (National Association of Industrial Technology, 1988, pp. 12, 19 & 27).

Industrial Technology Curriculum Components

The accreditation of baccalaureate degree programs requires the identification of program goals and, where appropriate, option or concentration goals. The goals and related educational objectives must meet the mission of industrial technology and the identified accreditation curriculum mix or foundation requirements. Each program and related options or concentrations are evaluated based upon the achievement of the identified program goals and objectives. The baccalaureate accreditation curriculum mix parallels the definition of industrial technology. The minimum and maximum foundation requirements are the following:

General Education
Humanities, English, History, Economics, Sociology, Psychology, Speech, etc. .... 18–36 Sem. Hrs.

Mathematics
Algebra, Trigonometry, Analytical Geometry, Calculus, Statistics, Computer Science, etc. .... 6–18 Sem. Hrs.

Physical Science
Physics, Chemistry, etc. .... 6–18 Sem. Hrs.

Management
Quality Control, Production, Planning and Control, Industrial Supervision, Industrial Finance and Accounting, Industrial Safety, Management, Facilities Layout and Materials Handling, Time and Motion Study, Industrial Communications, Business Law, Marketing, etc. .... 12–24 Sem. Hrs.

Technical
Computer Integrated Manufacturing, Computer Aided Design, Electronics, Materials Testing, Computer Technology, Packaging, Construction, Manufacturing Processes, etc. .... 24–36 Sem. Hrs.

Electives .... 6–18 Sem. Hrs.

(National Association of Industrial Technology, 1994, p. 30)

These curricular components must be integrated into the degree program. Basic mathematics, physical science, computer applications, and communication courses must be prerequisites for general or basic technical courses in each degree program. For example, courses in trigonometry, physics, computer literacy, and English composition may be prerequisites for engineering drawing, industrial processing, electronics, DOS operating systems, and automation courses. These courses may serve also as prerequisite courses for upper level major courses. The recommended sequence for teaching courses in each program must be identified and made available to students (National Association of Industrial Technology, 1994).

Each major and related concentration shall include identified competencies that are relevant for employment opportunities. The competencies should be identified by level based upon existing prerequisites. The program content shall be validated by an ongoing process that may consist of external experts, industrial advisory committees, and follow-up studies of program graduates. Accredited programs must include industrial experiences such as industrial tours, work-study options, cooperative education experiences, senior seminars, and/or industrial problem-solving experiences. Each program must have an industrial advisory committee which is required to meet at least once a year to review the program and/or to provide input for any major changes (National Association of Industrial Technology, 1994).

Other accreditation standards are related to instruction, faculty, students, program administration, facilities and equipment, computer systems, financial resources, library services, support personnel, placement services, educational innovations, and assessment. The program must have an appropriate balance between laboratory activities and theory and include problem-solving activities that reflect contemporary industrial procedures. Fifty percent of the faculty must be regular, full-time faculty with earned doctoral degrees. Faculty degrees must be related to their instructional assignments. The scholastic success of industrial technology students must be comparable to students enrolled in other curricula in the institution. The program's facilities and requirements must be suitable for meeting the program objectives and reflect contemporary industry (National Association of Industrial Technology, 1994).

The titles and composition of industrial technology programs vary depending upon national, state, and local needs. Some examples of different program titles are aerotechnology, aviation management, communications technology, computer-aided design, computer-integrated manufacturing, construction management, electronics, facility management, industrial distribution, manufacturing, packaging, plastics, polymers and coatings, product design, quality assurance, and telecommunication technology (National Association of Industrial Technology, 1994; National Association of Industrial Technology, 1993).

Administering Industrial Technology Programs

The *Industrial Technology Baccalaureate Program Directory* indicated that industrial technology is housed in a variety of schools or colleges with the largest percentage (24%) being in a category that included science and/or mathematics (applied sciences—8%, applied sciences and technology—12%, and science and technology—4%). Seventeen percent of the programs were housed in education and most of these programs were housed with existing technical teacher education programs. Engineering and/or engineering technology included another 15%, followed by schools or colleges of technology (14%). Other college/university categories that included industrial technology programs were agriculture, arts, business, and professional and human resources development. The term, technology, was used in half (65%) of the titles of the college/schools that housed industrial technology (National Association of Industrial Technology, 1993).

The housing and administration of industrial technology programs varies across the United States. Some programs are located in colleges of engineering and may use some of the engineering courses for preparation of industrial technology majors. At other institutions, industrial technology and engineering technology are organizationally within the same administrative unit. In engineering colleges, for example, industrial technology is often perceived as being a second class citizen when compared with engineering technology and/or engineering. In some cases, industrial technology may be housed in a department with trade and industrial teacher education, vocational teacher education, and/or technology teacher education. Multiple technical program departments require the faculty to collaborate in order for all programs to achieve their unique mission and goals. At some universities, industrial or engineering technology are the only technical programs that exist for preparing people for industry and, therefore, these programs often serve a unique role at these universities.

Typical Careers in Industrial Technology

Graduates of industrial technology programs are employed in a variety of technical management positions. Their job titles may be general in nature (such as technologist, industrial technologist, supervisor, assistant, associate or general manager) or related to a specific operation, process, or function (such as computer-aided drawing or design or computer-aided manufacturing technician, programmer, planner, supervisor, or coordinator; construction estimator, bidder, scheduler, subcontractor, or general contractor; electronics technologist, supervisor, or manager; facility planner, supervisor, or manager; inventory control planner, supervisor, or manager; manufacturing technologist, supervisor, or manager; and quality control or assurance technologist, supervisor, manager, or engineer). Some industrial technology graduates, even though they do not have an engineering degree, hold engineering job titles that have been assigned by industry (such as construction engineer, cost control engineer, facilities engineer, operations engineer, process engineer, production engineer, quality engineer). This occurs primarily because industry has titled many positions as engineering even though they do not require the qualifications of engineering graduates (Keith & Talbot, 1991; Israel, 1994).

Advanced Study, Associations, and Certifications

Graduates may pursue advanced study in master's degree programs in industrial technology, usually with an emphasis in a technical specialty. There are also opportunities to pursue a doctorate (Ed.D., Ph.D., or D.I.T.) in industrial technology, education, or in a related professional field.

The only national association representing the industrial technology profession is the National Association of Industrial Technology (NAIT). It has four divisions: industry, community college and technical institute, university, and student. Each division has officers and regional representatives. Graduates also have the opportunity to join the NAIT or other professional organizations in their technical area of interest. Epsilon Pi Tau is the honorary organization for professions in technology.

Faculty and graduates of accredited associate and baccalaureate degree programs may become Certified Industrial Technologists (CIT) for eight years. A graduate may become a Certified Senior Industrial Technologist (CSIT) after completing five years of job experience and 75 documented professional development units (contact hours). Every five years, CSIT's have to resubmit 75 additional hours of professional development activities to renew their certification. Graduates and faculty of non-accredited industrial technology programs may become a CIT as a result of passing a certification exam.

ENGINEERING TECHNOLOGY

Engineering technology programs prepare people to become technicians at the associate level and engineering technologists at the baccalaureate level. Engineering technology programs evolved in the technical institutes and became part of the engineering enterprise in the early 1900s. The American Society of Engineering Education (ASEE) gave recognition to engineering technology as a second or dual field in the engineering enterprise.

Definition of Engineering Technology

The Engineering Technology Council (ETC) of the ASEE has defined the engineering enterprise of the United States as follows:

> Professionals and para-professionals in engineering, engineering technology and related fields. Entry to professional positions in engineering requires at least a baccalaureate degree in engineering, engineering technology or a related field. Entry to para-professional positions

> requires a two-year associate degree in engineering, engineering technology or a related field. (Engineering Technology Council, 1991, p. 1)

Within this context, the ETC has defined engineering technology as follows:

> Profession in which a knowledge of the **applied** mathematical and natural sciences gained by higher education, experience, and practice is devoted to application of engineering principles and the **implementation of technological advances** for the benefit of humanity. Engineering technology education for the professional focuses primarily on analyzing, applying, implementing and improving existing technologies and is aimed at preparing graduates for the practice of engineering closest to the product improvement, manufacturing, and engineering operational functions. (Engineering Technology Council, 1991, p. 1)

The educational program emphasizes the application of (a) science, mathematics, and computer functions, and (b) technical sciences, including the knowledge and skills that enable graduates to test, evaluate, and/or make recommendations regarding technical devices, techniques, designs, and systems in their technical specialty.

The Junior Engineering Technical Society (JETS) compared scientists, engineers, technologists, and technicians as part of a spectrum of technical manpower in order to illustrate similarities and differences among each. They determined the following:

- Scientists are concerned with expanding people's knowledge. Their field is research.
- Engineers apply available scientific knowledge to plan, design, construct, operate and maintain complete technical devices and systems. Engineers develop technologies and innovations.
- Engineering technologists apply engineering knowledge to solve technical problems and organize the available work force, materials and equipment to design, construct, operate, maintain and manage technical engineering projects.
- Engineering technologists work closely with engineers to coordinate people, material and machines assigned to a project.
- Engineering technicians work with the scientists, engineers, and technologists, assisting them in the practicalities of their efforts, and complementing the arts and skills of the craftsmen. (1991, p. 1)

Figure 2–7 is a simplified diagram of the relationships among engineering-related fields. The basic context of the diagram was developed by the ASEE ad-hoc Definition Committee composed of members from the Technical College Council and the Engineering Technology Division. The diagram was used by Richard Ungrodt (1980) to explain the dimensions of the engineering profession.

> The rapid and continuing increase in engineering and scientific knowledge has brought with it a natural expansion of the technical manpower team which utilizes and applies new knowledge. In the early 1900's the engineers alone performed most all of the work related to their responsibilities. As the nature of their problem-solving work became more complex, it became necessary to train assistants and employ aides to help with the less complex and more routine work.
>
> The two dimensions of theory and practice have been used to classify the members in the professional/technical manpower spectrum. The scientific knowledge or theory dimension has received the most attention in engineering curricula studies of the past. More recently the interface between engineering and engineering technology has focused on the entry level, problem-solving, practical applications dimension. [Figure 2–7] illustrates the two dimensional view of the spectrum of engineering manpower and as it has expanded since the 1940's. (Ungrodt, 1980, pp. 5–6)

Figure 2–8 illustrates an updated version of the theoretical knowledge and practical application continuum.

Some overlap naturally exists among the different fields with the largest potential overlap existing between engineering technology and industrial technology. These two educational programs have a different heritage as engineering technology evolved from technical institutes and industrial technology evolved primarily from industrial arts and vocational trade and industrial teacher education. Even though each has a different theoretical background and program emphasis, overlap can occur if an engineering technology program emphasizes management or an industrial technology program emphasizes engineering application, applied calculus, science, and technical testing in laboratory courses.

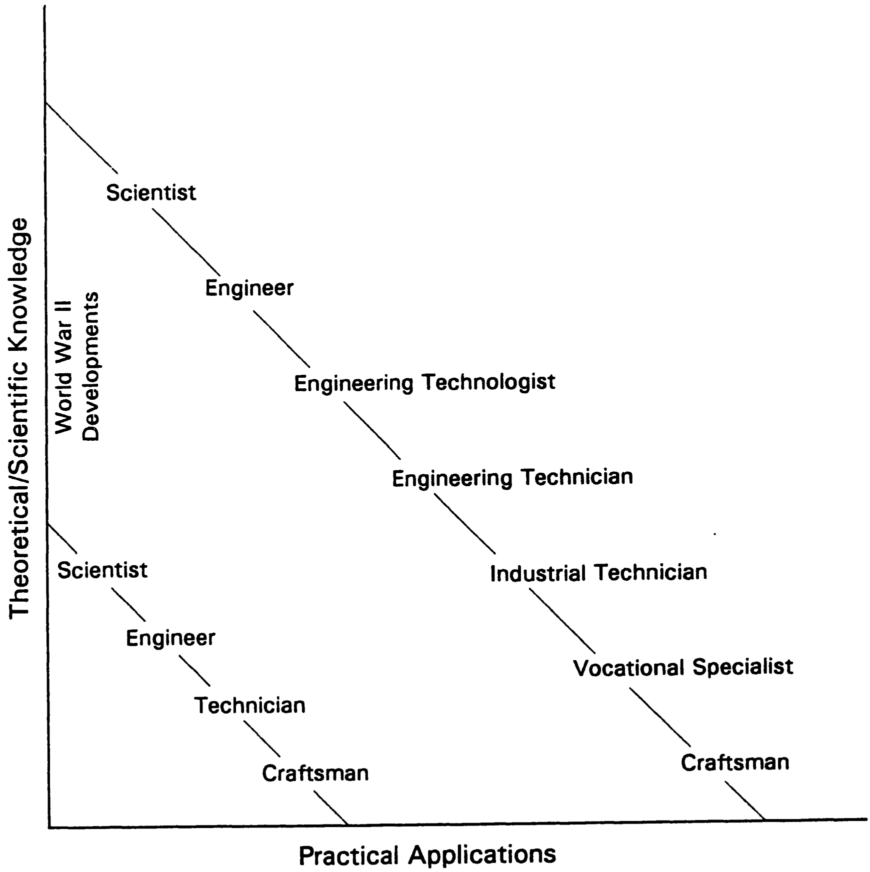

Figure 2-7: Comparison of engineering fields with theoretical knowledge and practical applications (Ungrodt, 1980, p. 12).

HISTORY OF ENGINEERING TECHNOLOGY EDUCATION

Four-year engineering technology programs evolved in the 1960s from two-year post-secondary technical institutes. The big push came from engineering as it was becoming more theoretical. Technical institutes, which emphasized the use of instructional laboratories to learn and apply engineering knowledge, developed engineering technology programs early in this century. The evolution of the dual entry into the engineering enterprise

Pre World War II

Scientist	Engineer	Craftsman	Artist

1940s: World War II

Mathematician	Scientist	Engineer	Craftsman	Artist

1950s: post World War II

Mathematician	Scientist	*Gap*	Engineer	Craftsman	Artist

1960s: post Sputnik

Mathematician	Scientist	Engineer	*Gap*	Technician	Craftsman	Artist

1970s:

Mathematician	Scientist	Engineer	Technologist	Technician	Craftsman	Artist

1980s: Increased competition

Mathematician	Scientist	Engineer	*Gap*	Technologist	Technician	Craftsman	Artist

1990s: World-Class quality

Mathematician	Scientist	Engineer	Eng. Technologist	Technologist	Technician	Craftsman	Artist

Figure 2-8: Updated comparison of the evolution of industrial technotons continuums (McCollum, 1977, Tillman, 1994).

concept resulted from the ASEE recognition of engineering technology associations and the development of an accreditation program for engineering technology two- and four-year programs.

Evolution of Technical Institutes

In 1895, Frederick Pratt of the *Technikum* in Germany introduced new meaning to the term "technical institute." The idea was to integrate a sequence of courses in mathematics, technological subject areas, and related shop and laboratory experimental work into one program (Henninger, 1967). The resulting curriculum would distinguish itself from the lecture series and self-study pattern of the popular mechanics institutes or athenaeum "... from which several of the prominent technical institutes have evolved" (Henninger, 1967, p. 9). The Pratt Institute, established in 1877, originally was a vocational high school. In 1892, it became a part of New York City's public education system, leaving the Pratt family with an art school and a domestic science school. In these schools, the Technikum concept was implemented by offering two-year integrated applied science-technical curricula (Henninger, 1967).

Since 1900, engineering education associations have consistently studied their own educational system. Since 1918, major studies have been conducted on a regular basis. Ungrodt (1982) reported that in 1918 a committee headed by Charles Mann completed a report entitled *A Study of Engineering Education*. The report identified both the status and elements of engineering education and noted that the field included practical application and problem solving. In 1923, during a Society for the Promotion of Engineering Education (SPEE) conference, a group of industrial and educational representatives met in Rochester, New York and "... adopted the term 'technical institute' to designate those schools offering two-year, terminal-technical training" (Ungrodt, 1982, p. 1). It was perceived that the graduates of the program would be called technicians (Ungrodt, 1982).

The concept of the technical institute was recognized and refined by Wickenden and Spahr in a study entitled *Report of the Investigation of Engineering Education 1923–29*. The two-volume report was published by the SPEE, which is known today as the American Society for Engineering Education (ASEE). About one-fourth of the 1,320 page report was devoted to the study of technical institutes. Volume two "... pointed out the need for technical institutes to provide post-high school, non-degree programs to train engineering technicians as supporting personnel required by the burgeoning industry in the United States" (Grayson, 1993, p. 136). Laurence Grayson (1993), the author of *The Making of an Engineer: An Illustrated History of Engineering Education in the United States and Canada*, went on to say that the report "... concluded that technical institutes could be more readily justified in many regions of the country than additional engineering colleges could, and that they were better suited than engineering schools to produce certain types of technically trained personnel" (p. 136). The report recommended that technical institutes should have "... their own distinctive character to provide positive appeal to a distinct group of individuals with genuine promise" (p. 136). The institutes should blend scientific and practical instruction and be staffed by people who knew industry. The SPEE gave recognition to technical institute faculty since the Wickenden and Spahr report noted that they suffered from professional isolation (Grayson, 1993). Nine topics identified unique to technical institutes became the basis for developing the first engineering accreditation criteria 15 years later (Ungrodt, 1982).

Harry Hammond, who served as the associate director of the Wickenden report, chaired two SPEE studies in engineering education entitled *Aims and Scope of Engineering Curricula* (1940) and *Engineering Education after the War* (1944). Another route to enter the engineering enterprise was suggested by Hammond. He noted there were two integrated engineering sequences: the technical-scientific stem and the humanistic-social sciences stem. The idea of providing a third sequence was proposed by Hammond in *Aims and Scope of Engineering Education*. During the fourth year, it was suggested that students be allowed to select one of three options:

> One option was for a technical terminal [engineering] program. A second option suggested preparation for additional years of advanced study. The third option proposed emphasizing subjects dealing with problem solving in the production enterprises and in the management of construction and of production. (Ungrodt, 1987, pp. 114–15)

The latter option has been labeled the engineering technology option and resurfaced in the Grinter report (Ungrodt, 1987).

The development of four-year engineering technology programs for entering the engineering profession was recommended by L. E. Grinter in his preliminary ASEE report (1953). Ungrodt (1987) reported the following:

> The 1955 [*Report on Evaluation of Engineering Education*] Grinter Report is considered by many to be instrumental in the development of the four-year engineering technology programs. The preliminary report proposed the need for two types of engineering programs: (1) a professional-general program whose graduates would move into the engineering problem solving area to supply the needs of industry, and

> (2) the professional-scientific program, providing a heavy complement of mathematics, science, and engineering science as a foundation for entry into a more advanced level of engineering studies. This preliminary proposal for bifurcated engineering programs was soundly rejected by academic personnel. (p. 115)

The final report did not include the professional-general program, but the professional-scientific was renamed engineering-science (Ungrodt, 1987).

In 1957–1958, the ASEE repeated the Wickenden and Spahr study on technical institutes and reported similar results (Henninger, 1967). The ASEE defined the technical institute as an "... intermediate strata of technical curriculums which are from one to three years' duration (full-time) beyond high school level" (Henninger, 1967, p. 19). The curriculum, which differed from vocational education, emphasized the understanding and the application of basic science and mathematics related to different technical fields of study. The purpose of instruction was similar to engineering except the process was briefer, with more emphasis on technical content instead of engineering science. Graduates of technical institutes were perceived to become engineering technicians who would be involved in applying, operating, developing, and testing engineering and scientific processes, and equipment. The high demand for technical people in industry resulted in technicians' (a) drafting, designing, and developing products, (b) installing and operating equipment, and (c) estimating costs, selling, and advising customers (Henninger, 1967).

The technical institute had some common curricular principles. Those identified in the 1957–1958 study were the following:

- Be directed toward a specific occupational area which is sufficiently attractive to draw qualified students.
- Place emphasis upon a sound understanding and appreciation of the basic principles and established scientific facts specially related to the selected subject field.
- Place emphasis upon practical application of established mathematical, scientific, and technological principles rather than upon derivation or theoretical development.
- Contain appropriate courses in communications and other general subject matter carefully selected to suit the objectives of the specific curriculum.
- Be developed or offered only in accordance with established needs.

- Be developed in scope of content and [at a] level of technical rigor to suit the capacity of the type of students whose enrollment is sought.
- Be organized and presented in such a manner as to give the student a clear realization of the fact that although he is receiving a sound preparation in essentials of his selected technology, his personal growth and advancement after graduation will depend upon his continuing effort to broaden his field of knowledge and understanding. (Henninger, 1967, pp. 31–32)

The increased interest in collegiate engineering at the end of the 19th and the beginning of the 20th centuries resulted in the reduction of the number of technical institutes (Henninger, 1967). However, the number of technical institutes increased from 13 in 1922 to 144 in 1957. A demand for technical institute graduates took place after World War II as veterans of the war used the G.I. Bill to continue their education. This resulted in many existing engineering technology programs either expanding their offerings or developing new programs. The merging of science and technical knowledge in electronic, aeronautical, mechanical, and chemical industries accounted for much of the rapid growth during the 1950s (Henninger, 1967).

Technical institutes evolved in three different arenas: private universities, public colleges and universities, and, later on, community colleges. Some of the institutes were the following: Academy of Aeronautics, Capital Radio Engineering Institute, Case Institute of Technology, City College of San Francisco, Cogswell Polytechnical Institute, University of Dayton Technical Institute, DeVry Technical Institute, University of Houston, Milwaukee School of Engineering, Mohawk Valley Technical Institute, New York State Agricultural and Technical at Alfred and Canton, Northrup Institute of Technology, Oregon Technical Institute, the extension service of the Pennsylvania State University, Division of Technical Institutes at Purdue University, RCA Institutes, Rochester Institute of Technology, Sinclair College, Southern Technical Institute, Wentworth Institute, and West Virginia Institute of Technology. A total of 144 schools were identified as offering technical institute curriculums in 1957–1958 (Henninger, 1967). Many of these programs evolved into four-year engineering technology programs.

Professional Association Activities

In June of 1941, the Technical Institute Division (TID) was formed and held its first meeting at the Society for the Promotion of Engineering Education. Also in 1941, the McGraw-Hill Book Company began publication of the *Technical Education News*, the first newsletter for the Division (Ungrodt, 1982). In 1946, the TID became a recognized division of the

ASEE with a TID representative on the ASEE Executive Committee (Gourley, 1993). During the time period 1946 to 1962, the Committee of 21 was established to provide overall leadership for the TID. Each year, seven individuals were appointed for a three-year term of office with the TID officers being elected from the Committee of 21 (Gourley, 1993).

In 1962, the ASEE underwent another reorganization. The TID, which became known as the Engineering Technology Division (ETC) in 1971, represented individual members from technical institutes. The Technical Institute Council (TIC) was established and its members represented institutions that had Engineers' Council for Professional Development (ECPD) accredited programs and who were institutional members of the ASEE. The TIC was renamed the Technical Institute Administrative Council (TIAC) in 1965, the Technical College Council (TCC) in 1971, the Engineering Technology College Council (ETCC) in 1981, and the Engineering Technology Council (ETC) in 1987 (Gourley, 1993). The name changes were representative of changes taking place in the profession and in the ASEE. The ETC is one of four institutional councils that are represented on the ASEE Executive Board.

The Division and Council have been very active over the years and their work has resulted in engineering technology achieving the status it has today within the engineering profession. The committees that were an active part of the TID from 1940 through 1962 were transferred to the TIC during the reorganization of the ASEE in 1962. During the 1940s, the publishing of the *Technical Education News* resulted in the communication of major events and the mission of technical institutes to a national audience. The Committee of 21 and the TID established standards for technical institutes (Gourley, 1993). In 1948, the McGraw-Hill Book Company and the ASEE agreed to establish the James H. McGraw Award program. Since June of 1950, an engraved certificate and monetary recognition have been awarded annually to a person in engineering technology education in the United States who has excelled in teaching, publication, and/or administration (Wear, 1993).

During the 1950s, Division committees devoted their attention to promoting engineering technology nationally, improving post-secondary teacher preparation, determining the role of general studies in technical institutes and engineering technology programs, studying enrollment and placement trends, surveying the success of graduates, analyzing curriculum trends and recommending areas of improvement, and establishing working relationships with professional associations who supported technical institutes and engineering technology education (Gourley, 1993). In the 1960s, engineering technology gained more status within the ASEE. Committee activities included establishing criteria for quality programs, promoting engineering technology sessions at the ASEE section meetings, implementing a teacher exchange program, defining the nature of four-year engineering technology programs, and developing new leadership for the profession (Gourley, 1993).

During the 1970s, the ETD and the Council continued to establish programs to advance engineering technology. The ETD, working with three other divisions, reestablished holding meetings with industrial personnel. Since 1976, these annual meetings have been held and have become known as the College Industry Education Conference (CIEC) (Gourley, 1993). In 1973, an informal discussion among engineering technology directors about common problems and issues resulted in the formation of the Engineering Technology Leadership Institute (ETLI) in 1976, which has developed into an annual conference to assist in the preparation of future leaders in the profession. An ETLI Executive Committee, constitution, and bylaws were established, with the major mission of providing an open forum for the discussion of problems related to the engineering technology community. The ETLI affiliated with the ASEE and the Engineering Technology College Council (ETCC), the new name for the TCC, in 1981. In 1987, the ETLI, the National Forum for Engineering Technology, and the Accreditation Board for Engineering and Technology (ABET) linked their annual meetings in Nashville and held a debate on five issues of common interest: faculty, curriculum, industry and professional, long-range engineering technology, and the engineering/engineering technology interface (Tilmans, 1993). Other events that took place in the 1970s were the ASEE agreeing to devote the May issue of the *Journal of Engineering Education* to engineering technology education, reestablishing section representatives, and publishing resource monographs (Gourley, 1993).

In 1981, a small group of engineering technology educators met after the ETLI annual meeting to discuss the publication of an engineering technology journal. With the support of the ETD and the ASEE, the *Journal of Engineering Technology* was printed for the first time in March, 1984 and has recently celebrated its 10-year anniversary (O'Hair & Wolf, 1993). Other major activities during the 1980s included the following: (a) conducting joint meetings of the ETD, the ETC, and the ETLI to outline long range goals and objectives, (b) implementing an ETD mini-grant program, (c) establishing written guidelines for both the ETD and the ETC, (d) establishing a national archives, (e) publishing monographs, and (f) holding special interest sessions at the annual ASEE conference (Gourley, 1993).

A program directory for engineering technology was published in 1990. The directory listed more than 400 institutions that offered over 1,700 engineering technology programs. The directory identified institutions, programs, degrees, TAC/ABET accreditation status of programs, and contact people (Gourley, 1993). In 1993, there were 315 accredited bachelor of science in engineering technology programs in over 90 subject matter areas at 110 colleges and universities, and 450 accredited associate degree programs in approximately 120 subject matter areas at 160 colleges and universities (American Society for Engineering Education, 1993b).

Accreditation Activities

The development of standards for post-secondary technical schools surfaced in 1940 from four different but related sources. In 1946, the first engineering technology programs were accredited by the Engineers' Council for Professional Development (ECPD). In 1980, the Accreditation Board for Engineering and Technology (ABET), originally the ECPD, became a stand-alone accreditation agency for engineering-related, engineering technology, and engineering programs (Ungrodt, 1982). The ABET (1991a) is made up of 21 participating professional bodies, one associate professional body, and five affiliate bodies with three commissions: the Engineering Accreditation Commission (EAC), the Technology Accreditation Commission (TAC), and the Related Accreditation Commission (RAC). Each is responsible for reviewing and implementing accreditation standards, overseeing the accreditation process, and making final accreditation decisions for each area they represent. The TAC accredits associate and baccalaureate engineering technology programs.

The growth of technical programs during and at the end of World War II resulted in the need to establish some standards. Over the years, four different organizations supported or became involved in the accreditation process. One organization, the Technical Institute Division, when formed in 1941, expressed the need for accrediting technical institute-type programs. At the same time, a second parallel organization known as the National Council of Technical Schools (NCTS), which represented private technical institutes, expressed an interest in accreditation. Since private institutes were excluded from the regional accrediting process, the NCTS implemented an accreditation program. A third organization, a Subcommittee on Technical Institutes, was organized. As the result of the ASEE recognizing the TID, the Subcommittee on Technical Institutes became a standing committee of the ECPD in 1964 and 1965 (Avtgis, 1993; Ungrodt, 1982).

The NCTS, made up of private technical institute administrators and program coordinators, was conceived as a council in 1943 and became formally organized in January, 1944. Technical institutes that wanted to become council members prepared documents for review and were visited by an evaluation team representing the Council. At the first annual conference in 1945, 28 delegates attended representing 19 technical institutes and two state universities (Avtgis, 1993; Ungrodt, 1982). "The committee of inspection reported: 15 schools approved for active membership; one school approved for affiliate membership; one school denied membership; one school deferred for further investigation; [and] two applications pending" (Ungrodt, 1982, p. 3).

The fourth organization, which has become the major accreditation agent, was the Engineers' Council for Professional Development (ECPD). It was established in 1932 and became the ABET in 1980. A number of technical institutions petitioned the ECPD to develop a program to accredit technical institute curricula. The concept challenged the major mission of the ECPD, which was started by professional societies to establish a uniform process of evaluating graduates to become acceptable members of the profession. In 1945, the Subcommittee on Technical Institutes was organized and reported to the Committee on Engineering Schools. The Subcommittee established eight regional committees and began a successful trial run of accrediting several institutions in the New England region. Formal evaluations took place and in 1946 the Subcommittee approved seven curricula at three institutions: Bliss Electrical School, Capital Radio Engineering Institute, and Wentworth Institute. By 1949, 19 institutions with 51 accredited curricula had been approved. This list grew to 28 institutions with 85 accredited curricula by October, 1954. In 1958, there were three major changes in the accreditation criteria: (a) the program being accredited must not be less than two academic years, (b) the term technology must be used to designate the technical institute curriculum, and (c) the implementation of a policy that required a separate examination and accreditation of geographically separate units and required day and evening programs from the same institutions (Avtgis, 1993; Ungrodt, 1982). These changes resulted in the establishment of accreditation criteria for two-year engineering technology programs and each existing stand-alone program had to meet the criteria.

In 1957, the ASEE was requested to evaluate technical institute education and publish their recommended guidelines. Their report, *Characteristics of Excellence in Engineering Technology Education*, resulted in some changes in the accreditation criteria. During 1964–1965, the Subcommittee on Technical Institutes was renamed the Engineering Technology Committee and became a regular standing committee of the ECPD. In 1966–1967, changes in existing guidelines were made, which allowed four-year engineering technology programs to be accredited. Brigham Young University was the first institution to receive accreditation for two baccalaureate curricula. This change resulted in the approval and implementation of different accreditation criteria for two-year and four-year programs in 1971 (Ungrodt, 1982).

The approval of four-year accreditation guidelines for engineering technology meant that both engineering and engineering technology had accreditable baccalaureate programs. This caused concern in the engineering profession. The profession had perceived engineering technology to be a two-year technician program. The change, which was supported by the ASEE, resulted in a dual, four-year accreditation route for graduates to enter the engineering enterprise (Avtgis, 1993).

When the ECPD was reorganized and became the Accreditation Board for Engineering and Technology (ABET) in January, 1980, their only responsibility was to accredit programs. All other committee responsibilities of the ECPD were transferred to one of the four councils of the ASEE: College/Industry Government, Engineering Deans, Engineering Research, or Engineering Technology. This change also gave the Technology Accreditation Commission (TAC), the newly reorganized ECPD Engineering Technology Committee, the authority to make final decisions for accrediting associate and baccalaureate engineering technology programs (Ungrodt, 1982).

Principles of Engineering Technology

The ETC prepared a set of principles for engineering technology, approved by the membership in December of 1990, that formed a mission statement for engineering technology. These principles are the following:

1. The ASEE's Engineering Technology Council (ETC) believes that the "engineering enterprise" includes professionals and paraprofessionals in engineering, engineering technology, and related fields.
2. The ETC supports a single definition of the engineering enterprise which: 1) is understandable to the general public, 2) describes the breadth of engineering education and engineering practice, 3) makes clear the various educational paths into the profession of engineering, and 4) emphasizes the interdependency of professional and para-professional engineering work, and explains the relationships among the educational paths to the engineering enterprise.
3. The ETC views engineering technology as an integral part of the engineering enterprise and holds that baccalaureate engineering technologists appropriately function as professional practitioners, rather than supporting para-professionals, in this enterprise. It is further held that an appropriate accreditation activity is necessary to support the uniqueness of this component. TAC/ABET serves this function.

4. The ETC believes that efforts to improve the professional status of all components of the engineering enterprise are important and should be encouraged, so long as access through methods of articulation to the highest levels of professionalism (including graduate education and professional licensure) remain open to all components of the enterprise.

5. The ETC supports the concept of the associate degree in engineering technology being the appropriate entry level preparation for employment as an engineering technician, and the baccalaureate degree being the appropriate entry level educational preparation for employment as a professional in the engineering enterprise. It further supports the continued use of the modifier "engineering" in describing the technology component of the enterprise.

6. The ETC believes that adequate bridging among engineering enterprise degree programming, including 2 year/4 year articulation, should be facilitated such that alternative career options within the enterprise may be undertaken with minimal additional required coursework.

7. The ETC supports access and participation for qualified engineering technology graduates through full membership in the appropriate professional societies, since engineering technology is an integral component of the engineering enterprise.

8. The ETC believes that professional registration is important, especially as it relates to those activities that directly affect the health, safety, and welfare of the public. Further, it supports the continuance of the industrial exemption, while recognizing the importance of registration in industry for some disciplines. The ETC further supports and encourages registration for all eligible engineering technology faculty, since they typically are engineering practitioners.

9. The ETC believes that it is the responsibility of each of the educational components of the engineering enterprise to develop and present programming that meets the social, economic, and human resource needs of the public, while protecting their health, safety, and welfare.

10. The ETC believes that, in light of long term projected shortages of technological human resources, strategies implemented should support increasing enrollments drawn from the diversity of American culture, with continuous quality improvement in each of the educational components of the engineering enterprise.

11. The ETC believes that it is in the best interests of international competitiveness and the wise utilization of limited resources to fully integrate, rather than fragment, the components of the engineering enterprise. (Engineering Technology Council, 1991, pp. 1–2)

Engineering Technology Curriculum Components

In 1992, the Technology Accreditation Committee (TAC) of the Accreditation Board for Engineering and Technology (ABET) Criteria for Accrediting Programs in Engineering Technology identified the requirements for accrediting associate and baccalaureate degrees in engineering technology. A minimum of 124 semester hour credits are required for the baccalaureate degree, but many accredited programs require more than the minimum to achieve their goals and objectives. A broad range of specialty programs are accredited by the TAC/ABET.

Criteria are specified for engineering technology programs in general. In addition, criteria are specified by program specialty area. General requirements include 48 semester hours of credit in technical sciences, technical specialties, and technical electives. Technical sciences are subject matter areas in a program that require the use of mathematics and basic science to apply technical knowledge and/or solve technical problems. The components of technical specialties are technical skills, techniques, and design. Technical skills and technique courses are the necessary skills and knowledge of appropriate methods, procedures, and techniques to do the following: (a) adapt existing technical procedures to new situations (e.g., select appropriate measurement procedures, determine an appropriate experimental procedure for a given situation, plan a technical experiment, and identify possible solutions to a technical problem), and (b) complete correctly given technical processes and procedures (e.g., processes, production procedures, instrumentation, and construction techniques) in a technical specialty area. The technical skills and technique courses must require students to record and communicate in a competent manner (Accreditation Board for Engineering and Technology, 1992).

Technical design courses are those that require students to learn, apply, and gain experience in carrying out established design procedures in their area of specialty. The design techniques used should follow established concepts developed by the engineering profession. Some examples are designing an air conditioning system to meet a specified need or a production operation to achieve a pre-established outcome. The design procedure must make use of mathematical operations, science concepts and principles, and/or computer operations (Accreditation Board for Engineering and Technology, 1992).

Technical electives include any related technical courses that support the student's specialty. Hence, a manufacturing engineering technology student may be able to take a program logic control course as a technical elective (Accreditation Board for Engineering and Technology, 1992). The technical component of the program also requires laboratory experiences whereby the students will do the following: (a) become familiar with test equipment, (b) plan and design experiments, (c) develop and implement experimental procedures, (d) implement measurement and data collection techniques, (e) use modeling procedures to validate existing or expected results, (f) document experimental work, and (g) report findings in writing or orally (Society of Manufacturing Engineers, 1992).

Another curriculum component consists of 24 semester hours of basic sciences and mathematics. Eight of the 24 hours must be in laboratory science courses that emphasize the understanding, measurement, and quantitative expression of nature and its phenomena. The basic science courses must be related to the technical specialty. Twelve of the 24 hours must be in mathematics, starting with college algebra or above and the mathematical component must include calculus. Technical courses must include the application of science and mathematics for accreditation. Computer courses do not fulfill this requirement (Accreditation Board for Engineering and Technology, 1992).

A third curriculum component is 24 semester hours of communications, humanities, and social science courses, with a minimum of nine hours in written and oral communications. Physical education and/or military science courses do not count in this area (Accreditation Board for Engineering and Technology, 1992). The remaining 28 semester hours or more should be designed for a well-rounded engineering technology graduate who can function successfully as an engineering technologist. The TAC strongly recommends that this component include courses that enable students to use the computer to solve technical problems along with a cooperative education experience for a maximum of eight semester hours, with no more than four hours counted as upper division credits in the program (Accreditation Board for Engineering and Technology, 1992).

The program requirements for a baccalaureate degree at most higher education institutions will generally exceed 124 degree hours. There are a number of reasons why this occurs. First, most universities have general education requirements that exceed the minimum requirements for accreditation. Second, the requirements for a comprehensive major usually exceed the 48 semester hours of technical courses. Third, the remaining hours are reduced by any required computer courses, cooperative education experiences, and physical education requirements.

The three common curriculum patterns in an engineering technology degree program are the comprehensive four-year program, the two-plus-two program, and the three-plus-one program. The addition of the upper division junior and senior courses to lower division courses requires that the latter provide the appropriate prerequisite knowledge and experiences for the advanced work. Hence, the lower division courses must include the mathematics, science, communication, and technology for students to be able to complete higher level technical specialty courses. The three-plus-one program requires students to devote the last year completing their selected area of specialization. Students usually complete a sequence of application and problem-solving experiences, which may include real-life projects from industry and/or a cooperative education experience (Accreditation Board for Engineering and Technology, 1992).

The TAC accreditation criteria identify specific technical science and specialty courses for different engineering technology programs. For example, thermodynamics, psychometrics, heat transfer, and fluid mechanics are required technical science courses for an air conditioning engineering technology program. Likewise, heating/cooling load calculations, ventilation principles, pipe and duct design, and system control are identified as technical specialty topics for air conditioning engineering technology. Technical science, specialty courses, and other requirements have been identified for automotive, bioengineering, chemical, civil, computer, construction, drafting/design, electrical/electronics, environmental, industrial, manufacturing, mechanical, mining, nuclear, and surveying engineering technology programs (Accreditation Board for Engineering and Technology, 1992).

Administering Engineering Technology Programs

A summary of the *Directory of Engineering and Engineering Technology Undergraduate Programs* (American Society for Engineering Education, 1993b) identified 27 engineering technology programs housed in schools, colleges, or departments of engineering technology or technology with additional programs located in schools or colleges of engineering. A combination of colleges or schools of engineering and technology or engineering technology accounted for eight more programs. Nine programs were located in schools or divisions of engineering technology. Technical-specific engineering technology programs were included in schools, colleges, or divisions that included science (8), business (1), professional (1), and other terms (10) in their titles. Some technical institutes identified specific programs such as electronic, mechanical, and civil as the name of the administrative unit.

In summary, engineering technology programs may be housed in colleges or schools of engineering, engineering technology, technology, natural or applied science, or a combination of these titles. Depending on the size and nature of the programs, there may be individual engineering technology departments based on a discipline such as chemical, computer, manufacturing, etc. Engineering technology, industrial technology, and/or technology programs may also be within the same administrative unit. In colleges of engineering, engineering technology programs are usually housed in a separate department or departments. Engineering administrators and/or engineering faculty perceptions of engineering technology, in large part, determine the status of the program(s), either as equal in stature or as a second class citizen when compared to engineering. In colleges of technology, it is usually understood that technical teacher education, industrial technology, and engineering technology programs have different emphases, different faculty criteria, and different defined roles for laboratory courses. These differences, when understood by administrators and faculty who agree to work together, can result in productive relationships when all programs are in a given department.

Typical Careers in Engineering Technology

Graduates of engineering technology hold many different industrial positions with many of them being related to their undergraduate area of specialization (aeronautical, air conditioning and heating, architectural, automation, biomedical, chemical, civil, computer, construction, electronics, mechanical, metallurgical, production, quality control, structural, surveying, textile, etc.). The rest of their job title usually designates their duties and responsibilities (application specialists, technician, engineering technician, designer, technologist, supervisor, superintendent, engineer, etc.) related to their specialty. Other more general job titles of graduates associated to their technical specialty are cost control, customer service, industrial, laboratory, plant layout, project, product, research and systems specialist, technician, technologist, supervisor, or engineer. Some engineering technology graduates, even though they do not have an engineering degree, hold engineering job titles that have been assigned by industry.

Advanced Study, Associations, and Certification

With the emphasis on life-long education, engineering technology administrators have had to give considerable thought to the opportunities they provide their graduates for advanced degrees. Presently, few higher education institutions offer master's degrees or doctorates in engineering technology. The program may emphasize the preparation of faculty for associate and baccalaureate programs or advanced technical subject areas with a system design, manufacturing, productivity, and/or management emphasis

(Ungrodt, 1987). In many instances, engineering technology graduates must complete a number of prerequisite courses or experiences to be admitted into master's or doctoral programs in business administration, engineering, or engineering management.

There are many opportunities for engineering technology graduates to belong to an honor society, become certified, and join professional associations. Tau Alpha Phi was founded at a technical institute in 1954 and has become the national honor society for engineering technology. The National Institute for the Certification in Engineering Technology provides the opportunity for technicians and technologists to become certified. Engineering and engineering technology professional associations offer certification programs in specific fields such as automotive, drafting, manufacturing, and quality. For example, the Society of Manufacturing Engineers provides the opportunity for industrial technology and engineering technology graduates to become certified manufacturing technologists as a result of passing a manufacturing engineering fundamentals examination. Professional associations in a number of technical fields encourage the participation of engineering technology professionals.

ENGINEERING

Engineering baccalaureate degree programs prepare people to create new devices and systems, which in turn create new technical knowledge. In addition to the traditional fields of engineering (such as chemical, civil, electrical, mechanical, military, mining, and metallurgical), there are many other fields that have evolved to meet social and cultural needs (such as aerospace, bioengineering, biomedical, computer, environmental, and water resources). Engineering education includes mathematics, basic science, engineering science, and engineering design courses. Engineering science courses such as materials, thermodynamics, mechanics, and fluid structure are usually not found in other technical education programs.

Definition of Engineering

Engineering is defined by ABET as the "... profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind" (Accreditation Board for Engineering and Technology, 1993b, p. 5). The Engineering Technology Council (ETC) and the Engineering Deans' Council (EDC) of the American Society for Engineering Education (ASEE) have recommended changes in the definition of engineering and engineering technology to further discriminate between the fields. The major recommendations are the following: (a) engineering involves the knowledge of advanced mathematical and natural sciences while engineering technology involves the knowledge of applied mathematical and natural sciences, and (b) engineering is devoted to the creation of new technology for the benefit of humanity while engineering technology is devoted to the application of engineering principles and the implementation of technological advances for the benefit of humanity (American Society for Engineering Education, 1993b; Engineering Technology Council, 1991). Their recommended definition of engineering identifies expected outcomes of graduates:

> Engineering is the profession in which a knowledge of advanced mathematical and natural sciences gained by higher education, experience, and practice is devoted to the creation of new technology for the benefit of humanity. Engineering education for the professional focuses primarily on the conceptual and theoretical aspects of science and engineering aimed at preparing graduates for the practice of engineering closest to the research, development, and conceptual design functions. (American Society for Engineering Education, 1993b, p. 2; Engineering Technology Council, 1991, p. 1)

Inherent differences between an engineer and a scientist have been well-documented. Walker (1961) reported that "science aims at the discovery, verification, and organization of fact and information . . . while . . . engineering is fundamentally committed to the translation of scientific facts and information to create machines, structures, materials, processes, [systems] and the like that can be used . . ." (pp. 419–421). The engineer creates what has not existed before (new products, devices, structures, materials, processes, and systems) through the use of science, mathematics, and engineering science (Duderstadt, Knoll, & Springer, 1982). Confusion occurs when an engineer discovers or produces new knowledge or a scientist uses the knowledge to produce a product, device, process, or system (Kemper, 1982).

History of Engineering Education

Unlike technology education, industrial technology, and engineering technology, the history of engineering and engineering education has been well documented both nationally and internationally. Emmerson (1973) has described the social history of engineering education from the Renaissance through the beginning of the 20th century in Germany, England, France, Russia, Canada, United States, Switzerland, Holland, Italy, Sweden, and Japan. Several introductory engineering textbooks trace the history of engineering through to the present. Beakley, Evans, and Keats (1986) have one of the best abbreviated histories of engineering. There are also books that describe the history of engineering in America.

The most complete and up-to-date history of engineering education in the United States and Canada was written by Grayson (1993). The author divided the history of engineering education into eight major topics:

- The Setting
- The Genesis: 1862 and Before
- The Period of Growth: 1862–1893
- The Period of Development: 1893–1914
- The Period of Evaluation: 1914–1940
- The Scientific Period: 1941–1970
- Diversification: 1970–1990
- The Future (p. xiii)

In *The Setting,* Grayson (1993) noted that "... 1893 was the time of contrasts and change. The census of 1890 officially marked the end of America's frontier, although significant westward movement continued for many years. After the 1890s, the country quickly became urban and industrial" (pp. 1–3). Modern engineering began in France in 1976 as an outgrowth of the Corps du Génie. The Corps never came into existence as an operating military engineering school until 1749. Jean Rodolphe Perronet, chief engineer of bridges and highways, was given authority to establish a school within the Corps which was renamed the École des Ponts et Chaussees, the first school of engineering in the world (Grayson, 1993).

The United States' War of Independence created the need for military engineering schools. In 1778, the United States Congress passed a resolution establishing a military engineering department, but no school was created. A military school was started at West Point in 1774, but was suspended two years later because the school, the old provost prison, burned. In 1802, Congress established the United States Military Academy at West Point. Colonel Sylvanus Thayer, who was appointed superintendent in 1817, organized West Point similar to the École Polytechnique school in France (Grayson, 1993).

Many different public and private technical education institutions and programs emerged during the 18th and 19th centuries. Voluntary self-improvement programs, evening schools, mechanics institutes, and specialized public schools did not meet the demand for the number of highly skilled people needed for public works projects and industrial development (Grayson, 1993).

Engineering education was conceived in the United States as taking place at the collegiate level and being directed by engineering educators. This was in contrast to the common practice of practitioners, through professional associations, directing the educational process for such professionals as lawyers, doctors, and dentists which required the completion of apprenticeships. Engineering, which was regarded as utilitarian, did not have the same status as these other professions. Admission standards were lower and the curriculum was less demanding (Grayson, 1993).

The first private engineering college in the United States was established by Alden Partridge after he left the West Point Academy as their first acting superintendent. He established the American Literary, Scientific, and Military Academy in 1819, which later became Norwich University in Norwich, Vermont. The curriculum included military subjects and civil engineering. He also established similar schools in Portsmouth, Virginia in 1839 and in Brandyware, Delaware in 1853 (Grayson, 1993). Other famous engineering schools established during the 1800s were the following:

- The Rensselaer School in 1824 at Troy, New York which gradually introduced engineering and awarded the first civil engineering degree in 1835. Rensselaer Institute was reorganized as a polytechnic institute based upon the École Polytechnique and the École Centrale des Arts et Manufactures by Benjamin Franklin Greene. The name changed to Rensselaer Polytechnic Institute in 1861.
- The University of Virginia in 1814 expanded its program to include natural philosophy, military and naval architecture, civil architecture, and technical philosophy. A School of Civil Engineering was established in 1835. The school closed in 1846 because of a depression.
- The University of Alabama began teaching civil engineering in 1837. A depression closed the program in 1846.
- The College of William and Mary (Virginia) began a School of Civil Engineering in 1836. It closed in 1839 because of a depression (Grayson, 1993, pp. 28–33).

By the end of the depression, there were only two well-known engineering schools in operation—West Point and Rensselaer School.

Changes made in the curriculum at the Rensselaer School defined the nature of engineering education in the United States. The change involved shifting "... from preparing a specialist with specific skills to meet the occupational requirements of the day to the education of a generalist who could more easily adapt to meet changing needs, but had less immediate utility" (Grayson, 1993, p. 33). The program was expanded from one to three years in length. Since the program was too advanced for the prevailing preparatory education, a beginning year was added to prepare students for their formal three years of engineering education. By 1846, only about 300 engineers had graduated from all the engineering programs, excluding the graduates from the West Point Academy (Grayson, 1993).

Engineering schools struggled to survive through the time period of the Civil War, but they experienced tremendous growth after the War. There were fewer than two dozen active engineering schools in the United States by the end of the Civil War. Three major events took place in 1862 that resulted in the formation of 70 engineering schools by 1872. They were the passage of the Homestead Act which prompted a westward migration, granting a charter for the construction of a railroad from Nebraska to California, and the passage of the Morrill Act. Some of the newly established schools were the School of Mines at Columbia (1864), Worchester Free Institute (1868), Thayer School of Engineering at Dartmouth College (1867), and Stevens Institute of Technology (1871). Engineering programs were also established at Cornell University (1868), Iowa State University (1858), University of Nebraska (1869), The Ohio State University (1870), Michigan State University (1855), University of Illinois (1867), and Purdue University (1869). Three out of six colleges at the University of California (1869) were engineering colleges (Grayson, 1993).

By 1892, there were approximately 100 schools of engineering with an annual graduation rate of approximately 1,200 students. In addition, the administrative structure and instructional delivery system of using deans, department chairpersons, the elective system, seminars, recitations, lectures, major fields of study, credit hours, and course numbering systems had been established in American higher education and engineering education. Yet, the diversity that existed among the different engineering programs resulted in significant differences in standards, course content, the balance between general and engineering education, the mix of theory and practice, and the length of study for the degree. The diversity in instructional strategies, when placed along a continuum, ranged from teaching almost exclusively science to a heavy emphasis on practical training (Grayson, 1993).

Major engineering associations that evolved were the American Society of Civil Engineering (ASCE) which was founded in 1852, the American Institute of Mining which was founded in 1871, and the American Society of Mechanical Engineers (ASME) which was founded in 1880. The development of electrical and chemical engineering programs resulted in the establishment of the American Institute of Electrical Engineers (AIEE) in 1884 and the American Institute of Chemical Engineers (AICE) in 1908

(Grayson, 1993). Other professional associations organized around different engineering fields were founded later.

After 1893, the International Congress of Engineering determined that the process of educating engineers was as important as the engineering specialty being learned. A Division E conference, attended by 70 people, discussed engineering education. The Society for the Promotion of Engineering Education (SPEE) was founded in 1893 and later became the American Society for Engineering Education (ASEE). Within one year, its membership grew to 156 members (Grayson, 1993).

The expansion of industry, especially in the textile industry and the mass production of farm utensils and other products, created a need for industrial engineering. Engineering programs and courses were developed in textiles, textile manufacturing, refrigeration, coal mining, copper mining, agriculture, railroad transportation, and illumination. An SPEE committee reported in 1904 that there were over 90 different engineering degree programs with the major fields being civil, mechanical, electrical, mining, and general. In 1904, the Society for Heating and Ventilation (SHV) and the American Society of Refrigeration Engineers (ASRE) were established, followed by the creation of the American Concrete Institute (ACI) and the Society of Automobile Engineers (SAE) in 1905. The Illumination Engineering Society was founded in 1906 (Grayson, 1993).

The laboratory method for instructing engineering students gained prominence. This method evolved because of the growth of electrical and mechanical engineering and their emphasis on demonstrating scientific and engineering science principles. Other initiatives that changed engineering education were the establishment of engineering experimental stations, providing technological assistance to industry, providing part-time work and cooperative education programs for engineering students, industries paying engineering schools for the training of their employees, and the licensing or registration of engineers (Grayson, 1993).

The SPEE grew to 1,339 individual members and 47 institutional members by 1914. This put the SPEE in a position of assuming a leadership role and developing a system for evaluating engineering education. In 1907, the SPEE formed a joint Committee of Engineering Education. The Committee was made up of representatives from the American Society of Civil Engineers (ASCE), the American Institute of Mining Engineers (AIME), the American Society of Mechanical Engineers (ASME), the American Institute of Electrical Engineers (AIEE), and the American Chemical Society (ACS). "The committee was charged to examine all branches of engineering education, including research, graduate professional courses, undergraduate institutions, and the proper relations of engineering schools to secondary industrial schools, and to recommend the degree to which the curricula of engineering schools should be common" (Grayson, 1993, p. 122). After 10 years, Charles R. Mann took charge of the committee and a report was issued in 1918. The report reviewed the status of engineering education in the United States and recommended the following: (a) the use of standards or tests to determine whether students comprehended the coordinated knowledge that was understood by educators and employers, (b) students shouldn't be required to spend more than 48 hours a week studying, and (c) the establishment of a classification system of work performed by engineers (Grayson, 1993). The report strongly suggested that engineering education move away from in-depth specialization and focus on analytical competencies expected of all engineers. Hence, the "... extreme diversification of curricula which had been growing for several decades was reversed, and a period of consolidation followed" (Grayson, 1993, p. 132). Engineering programs developed general types of curricula that were perceived as being useful to a wide range of different engineering occupations.

World War I interrupted the normal way of doing business for engineering schools. Semesters were condensed so graduates could join the service earlier. Second and third year engineering students enlisted in the Armed Services. The SPEE, working with the Council of National Defense, recommended that engineering schools offer eight weeks of intensive and technical training for people drafted by the War Department. The War Department also created the Student Army Training Corps to prepare engineers for the Army and the Navy. The program, which condensed semesters to eight, 12 week terms was short lived. The war was over when the program was in its third week (Grayson, 1993).

The interruption caused by the war provided the opportunity to de-emphasize specialization and concentrate more on the general competencies expected of all engineers. It also provided the opportunity for engineering education to place more emphasis on management and the organization of production systems. State registration and licensure of engineers continued to expand. In 1920, the National Council of State Boards of Engineering Examiners was established to promote uniformity in the administration of state registration laws (Grayson, 1993).

In 1923, a second major study of engineering education was initiated which has since become known as the Wickenden or the Wickenden and Spahr report. Harry Hammond, the associate director, became the director of other SPEE studies of engineering education. The Board of Investigation and Coordination was established by the SPEE to complete the study. The extensive report, published in two volumes in 1929, examined every aspect of engineering education in the United States. It recommended that an agency be established to set standards and inspect engineering schools for compliance with the standards. Hence, the Engineers' Council for Professional Development (ECPD) was established with accreditation visits taking place in 1935. One-hundred twenty-five engineering schools had their programs accredited by 1940 (Grayson, 1993). A second major finding of the Wickenden and Spahr study was that technical institutes provided post-high school, non-degree technical education programs. Since the report noted that faculty of technical institutes suffered from a sense of professional isolation, the SPEE allowed technical institutes to join as institutional members (Grayson, 1993).

Four other major issues addressed during what Grayson refers to as The Period of Evaluation were the following: (a) a concern about the pedagogical training of engineering faculty, (b) a lack of knowledge and ability for engineers to make appropriate decisions about the use of engineering devices and systems in society and culture, (c) the role of general education in engineering education, and (d) the expansion and nature of graduate education in engineering. Presidents of the SPEE in 1901, 1911, and 1912 expressed concern about the failure of faculty to understand the purpose and principles of engineering education and their need to use appropriate methods of instruction to achieve desired results. Summer school faculty educational programs were implemented and sessions were held on specific educational topics. They were attended by both junior and senior faculty members and the success of the program resulted in the SPEE becoming the leading proponent for improving instruction in engineering education (Grayson, 1993).

The need for engineers to become socially aware and responsible has been partially attributed to a letter sent by President Franklin D. Roosevelt to the SPEE in 1936. President Roosevelt questioned if engineering education was providing the moral, ethical, social, and civic responsibilities for engineers to make appropriate social decisions. Harry Hammond, President of the SPEE, responded to the President by noting, according to Grayson (1993), ". . . that there was a clear trend toward the broadening and enrichment of engineering curricula, with more emphasis on economics and social sciences . . . . [in addition] that in engineering subjects, greater emphasis was being placed on the fundamentals of science and technology and less on technical specialties" (p. 139). The criticism continued and peaked when, in 1939, the National Society of Professional Engineers joined forces with other professional engineering groups to recommend a change in a New York state education law. The proposed change would have required engineers to successfully complete two years of liberal arts and four years of engineering college work to become licensed in New York state. The proposal resulted in the SPEE appointing a committee to study the topic. A report on the aims and scope of engineering curricula determined the following: (a) the four-year baccalaureate degree program was appropriate for a large majority of engineering students, (b) the graduate program should be extended to five or six years for in-depth technical study, (c) the undergraduate program should provide a thorough grounding in basic science, social philosophy, and the ability to express reflective and critical thought, and (d) the undergraduate engineering education program should include applying science and engineering methods to solve actual problems (Grayson, 1993).

Graduate engineering education programs continued to grow. Prior to 1890, there were only six higher education institutions offering graduate programs. In 1922, there were 368 graduate students enrolled in 18 advanced degree programs, and by 1938, there were around 5,000 graduate students enrolled in 75 schools offering graduate programs. Fifty percent of the students were enrolled at seven schools while 33% of the institutions had less than 10 students each. The engineering graduate programs followed the M.S. and Ph.D. patterns that were commonly found in the arts and sciences, instead of the patterns used by medicine, dentistry, or law. Most graduate engineering education was related to in-depth specialization and/or research, even though there was another mission—the preparation of engineers to become faculty members. The emphasis on research resulted from an increase in grants from industry and government (Grayson, 1993).

The *Scientific Period* was characterized by engineering schools assisting in World War II, changing the curriculum to emphasize the interface between science and technology, and addressing the changes that were taking place in industry. After the bombing of Pearl Harbor, Andrey A. Potter, a previous president of the SPEE, was appointed as an expert consultant to the United States Office of Education and he prepared a proposal for the Defense Council and Congress. Congress authorized the Engineering Defense Training program to train naval architects, draftsmen, marine engineers, aeronautical engineers, machine tool designers, and other engineers. The program title was changed to Engineering, Science, Management War Training. Over a five year period, 60 million dollars were spent with 45 million going to 227 colleges and universities for offering 31,465 courses to train 1.3 million people. World War II proved to be less disruptive to engineering education than was World War I because of what had been previously learned (Grayson, 1993).

In 1946, the SPEE changed its name to the American Society for Engineering Education (ASEE) and an independent organization, the Engineering College Research Association, became a council of the ASEE. A joint committee was appointed between the two groups to study how engineering research efforts could be funded by the federal government. Their efforts resulted in engineering research being funded by the Research

Foundation Bill, which later became the Science Foundation Bill (Grayson, 1993).

During the war, major research and development efforts took place in petroleum production, synthetic rubber, medicine, electronics, aeronautics, the structure of materials, the processing of materials, and atomic energy. This research laid the basis for significant commercial applications related to these fields after the war. These developments, plus Russia's launching of Sputnik in 1957, determined how dependent the United States was on European scientific research as a source of ideas and principles for advancing American industrial capability. Hence, there was a need for new and advanced knowledge as well as identifying shortcomings in engineering education (Grayson, 1993).

The ASEE undertook studies to improve teaching and curricula in engineering education. A special steering committee, headed by L. E. Grinter, recommended in a 1952 report that in-service teacher education programs be established to aid engineering faculty in improving their methods of instruction. Action was taken and two-day summer workshops were implemented involving new and senior faculty. Success was limited because of the growing demand for faculty to do consulting and to conduct research. Therefore, another committee was formed to determine how quality teaching could be recognized and what incentives could be used to encourage faculty to improve their primary function of teaching. In 1960, the ASEE, in cooperation with the Pennsylvania State University and the Ford Foundation, initiated two-week summer institutes on effective teaching for engineering faculty. From 1960 through 1963, 247 participants from 130 schools took part in the funded workshops. Regional workshops were conducted from 1966–1972 with over 3,200 teachers attending the institutes. The Educational Research and Methods Division of the ASEE has continued to offer the institutes annually at the ASEE annual conference (Grayson, 1993).

The evaluation of engineering education that started with Mann, Wickenden and Spahr, and Hammond continued through the 1980s. In 1940, Hammond's committee report, *Aims and Scope*, noted that engineering education should stress fundamentals in the undergraduate program and the curriculum should be organized in a parallel sequence of science and technology courses and in humanistic and social aspects subjects. World War II interrupted plans of action to follow up on this report. Another committee, chaired by Hammond, was formed after the War and it arrived at the same conclusions. The report noted that engineers "... required a deeper understanding of fundamentals that could be applied broadly and less emphasis on current technical practices" (Grayson, 1993, p. 186). It also recommended that graduate education be broadened to include all areas of advanced specialization and that technical institute programs be strengthened through accreditation which would result in industry being more receptive of their graduates (Grayson, 1993).

In 1951, the ECPD asked the ASEE to study ways engineering education could keep pace with the rapid developments in science and technology and how future engineers should be educated to provide professional leadership. In 1955, the Grinter report stated that undergraduate engineering education curricula should be divided into integrated stems that included the humanities and social sciences, mathematics and basic sciences, engineering sciences, engineering specialty subjects, and electives. The report also noted that the undergraduate curriculum must prepare some graduates for immediate employment and others for graduate study (Grayson, 1993). The preliminary report recommended that there be two undergraduate engineering curricula: a professional-general and a professional-scientific. It was also recommended that accreditation standards be established for each curriculum. The scientific-based program would be concerned with research and development and the general program would focus on preparing engineering personnel for production, construction, operations, and sales. The Engineering Deans' Council of the ASEE did not support this recommendation, hence, the report was rewritten to support the scientific curriculum track (Ungrodt, 1980).

In 1961, the ECPD asked the ASEE to undertake another study known as the Walker report on the *Goals of Engineering Education* or the *Goals Report*. The preliminary report included two recommendations that caused heated debate within the profession. The first recommendation was that the master's degree be considered the first professional degree with the bachelor's being the general degree suitable for entry into employment. Engineering educators felt such a recommendation would downgrade the baccalaureate degree. The second recommendation was that the ECPD accreditation functions be given to an engineering college. The two controversial recommendations were rewritten and the report was issued in 1968. The report served as the basis for extensive discussion but led to very little action (Grayson, 1993).

The Hammond and Grinter reports resulted in the establishment of other committees to continue to improve engineering education. The final report of the Humanistic-Social Science Research Project, entitled *General Education in Engineering*, was distributed in 1956. It provided detailed guidelines for improving and integrating humanities studies throughout the engineering curriculum. The engineering curriculum, by the end of the 1960s and 1970s, was outlined to ". . . incorporate the natural sciences, social sciences, humanities, and communication arts into a strong core of mathematics, engineering science, and analysis, and tried to bring these intellectual disciplines and fields of knowledge to bear on real and contemporary problems of society" (Grayson, 1993, pp. 187–190). As previously indicated, emphasis was placed on developing the intellect of engineers so they would be able to apply knowledge instead of developing specific engineering job skills (Grayson, 1993; Ungrodt, 1980; Ungrodt, 1987).

In 1955, the ASEE was located at the University of Illinois. W. Leighton Collins was elected secretary of the executive board and worked half-time for the ASEE with a staff of three full-time secretaries, a bookkeeper, and a quarter-time editor. When the ASEE moved to Washington, D.C. to be close to other education associations, the ASEE hired a full-time executive director who was in charge of 14 staff people.

Grayson labeled the restructuring of engineering education from 1970 through 1990 as *Diversification*. He noted the following:

> [During] . . . this period, the undergraduate curriculum was completely restructured and updated, with a turn away from the teaching of technological skills and techniques to a focus on engineering sciences, which were developed into a coherent body of knowledge. A large number of engineering disciplines and subdisciplines associated with advanced technologies were introduced, and a system of associated and baccalaureate degree programs in engineering technology were established to augment the engineering programs. A comprehensive system of graduate education was created, doctoral enrollments increased, and in many institutions extensive programs of research were established. The curriculum changes were accompanied by the creation of a large number and array of modern textbooks at both the undergraduate and graduate levels, as well as a vast number of research publications. (Grayson, 1993, pp. 219–220)

Diversification was used as a title of the era to note major changes in the student bodies and faculties. There was an increased diversification in gender, racial composition, national origin, and special needs. A more international or global perspective also evolved. Women receiving baccalaureate engineering degrees increased from 0.8% in 1970 to 15.4% in 1990. A similar pattern occurred for minorities. African-American students increased from less than 1% to 3.6%. Hispanic-Americans experienced an increase from 1.8% to 3.2%. The number of Asian-Americans increased from 1.4% in 1973 to nearly 10% in 1990. Overall, the enrollments of minority groups at both the undergraduate and graduate levels in engineering increased through 1990 while the total engineering enrollment of United States citizens declined from 1983 through 1990 (Grayson, 1993).

International students have had a significant impact on engineering graduate education and the composition of engineering faculty. In 1970, international students accounted for 505 or 14% of the 3,620 doctoral degrees awarded in the United States. By 1990, this changed to 49% of the 5,424 degrees granted. This increase helped offset the drop of United States citizens and permanent residents pursuing engineering degrees (3,115 in 1970 to 1,768 in 1980). Unlike Canada, the United States did nothing to discourage foreign nationals. About 50% of the internationals who received doctoral degrees remained in the United States. Since they could not be employed in the United States defense industry, they sought employment in other industries, as researchers in engineering schools or as faculty members. Their inability to communicate effectively with American students, faculty, and staff caused concern. Nevertheless, by the mid-to-late 1980s, over half of the new engineering faculty positions were filled by internationals who had received their doctoral degrees in the United States (Grayson, 1993).

During the 1970s and 1980s, there was an increased emphasis on research. Presently, colleges and universities are performing about half of the basic research in science and engineering which is being supported by the federal government. Research conducted in engineering schools has increased from $288 million in 1970 to over $2.4 billion in 1990. The emphasis on research has resulted in engineering schools having a close relationship with the federal government and industry, but has caused faculty to devote less time to teaching (Grayson, 1990).

A shortage of engineering faculty was identified in a two-year study conducted by the ASEE and the American Association of Engineering Societies. Upon completing the study, the ASEE broadened the scope of the study to include all factors affecting the quality of engineering education. The project concluded that teaching was the primary function of engineering faculty and recommended that universities provide the support and the means for achieving this goal. The study also noted that graduate engineering education programs had the capacity for additional students and emphasis should be placed on recruiting United States engineering students to become faculty members (Grayson, 1993).

In 1986, the ASEE appointed another committee to determine ways of addressing the most pressing problems in engineering education. The report, *A National Action Agenda for Engineering Education*, noted that undergraduate programs cannot be expected to expand indefinitely to include the ever increasing amounts of technical and non-technical knowledge deemed necessary for an engineering career. The curriculum must be designed to provide the necessary knowledge base and processes for career-long learning. The report suggested that "... the objectives and purposes of undergraduate laboratory instruction be rethought and more cost-effective approaches developed, and that engineering design, leading to the manufacturing and construction processes, should be given a more central role in undergraduate curricula" (Grayson, 1993, p. 239). At the graduate level, the task force recommended the following: (a) more graduate programs be directed to engineering practice instead of research, (b) more emphasis be placed on design, development, and manufacturing, (c) more incentives be developed to encourage United States engineering students to earn doctorates and become faculty members, and (d) a more integrated system be developed to provide career-long educational opportunities for practicing engineers and faculty (Grayson, 1993).

Goals of Engineering

The goals of undergraduate engineering education, as identified by the Panel of Undergraduate Engineering Education (Engineering Undergraduate Education, 1986), are the following:

- To prepare graduates to contribute to engineering practice by learning from professional engineering assignments;
- To prepare them for graduate study in engineering; and
- To provide a base for life-long learning and professional development in support of evolving career objectives, which include being informed, effective, and responsible participants within the engineering profession and in society. (p. 9)

It is understood that the baccalaureate degree in engineering should provide a base and a means for life-long learning and not just preparation of a person to perform a particular job for a particular industry. Within this context, the objectives of undergraduate engineering curricula are the following:

1. To provide an understanding of fundamental scientific principles and a command of basic knowledge underlying the student's field.
2. To convey an understanding of engineering methods such as analysis and computation, modeling, design and experimental verification, as well as experience in applying these methods to realistic engineering problems and processes.
3. To provide the student with the following:
    a. An understanding of social and economic forces and their relationship with engineering systems, including the idea that the best technical solution may not be feasible when viewed in its social, political, or legal context;

b. A sense of professional responsibility developed through consideration of moral, ethical, and philosophical concepts; and

c. Mastering of the ability to organize and express ideas logically and persuasively in both written and oral communication. (Engineering Undergraduate Education, 1986, pp. 9–10)

It is expected that summer jobs, cooperative education experiences, internships, and supervised industrial project experiences will be required to achieve these objectives (Engineering Undergraduate Education, 1986).

The Engineering Accreditation Commission (EAC) of the ABET identifies accreditation criteria for basic (undergraduate) and general advanced (five or more years and/or a master's degree program) engineering programs. Objectives for the basic level, which include the previously identified goals and objectives, are the following:

1. A capability to delineate and solve in a practical way the problems of society that are susceptible to engineering treatment,
2. A sensitivity to the society-related technical problems which confront the profession,
3. An understanding of the ethical characteristics of the engineering profession and practice,
4. An understanding of the engineer's responsibility to protect both occupational and public health and safety, and
5. An ability to maintain professional competence through life-long learning. (Accreditation Board for Engineering and Technology, 1993a, p. 5)

Engineering Curriculum Components

The basic engineering education curricular components are mathematics, basic sciences, humanities, social sciences, engineering sciences, engineering design methods, and an engineering specialty. The program content must be integrated in such a way that it will enable a graduate to function as an engineer (Accreditation Board for Engineering and Technology, 1993a). Minimum curricular components including specific criteria and hours are specified by the EAC/ABET. A half semester is equal to 16 semester or 24 quarter hours or one-eighth of the total program, if the program is less than 128 semester hours (192 quarter hours). One year of appropriate combination of mathematics and basic sciences (32 semester hours) is required. Studies in mathematics must be beyond trigonometry. The studies must include differential and integral calculus and differential equations. Additional work is encouraged in one or more of the following: probability and statistics, linear algebra, numerical analysis, and advanced calculus. Basic sciences must include both general chemistry and calculus-based general physics with at least a two-semester sequence in either area. Additional work in basic sciences may be required, depending upon the curriculum requirements of a specific engineering discipline. Computer programming or computer skills may not be used to satisfy the mathematics and basic science requirements (Accreditation Board for Engineering and Technology, 1993a).

Sixteen semester hours or one-half year of humanities and social sciences are required. The humanities and social sciences must make engineers aware of their social responsibilities and enable them to implement a procedure for making decisions. Traditional and non-traditional (e.g., technology and human affairs, history of technology, professional ethics and social responsibility) humanities and social science subjects are appropriate. Subjects in accounting, industrial management, finance, engineering economics, and military, usually do not meet the humanities and social sciences requirement (Accreditation Board for Engineering and Technology, 1993a). One and one-half years of engineering sciences and design (48 semester hours) are also required. Engineering science studies must use mathematics and basic sciences to carry out engineering practices (e.g., mechanics, thermodynamics, material science, and electronic circuits). At least one engineering science course outside the major disciplinary area is required. Engineering design is the decision process used to devise a system, component, or process to meet specified needs. Basic sciences, mathematics, and engineering sciences must be used. Fundamental design elements include establishing objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The design process must include student creativity, use of open-ended problems, use of modern design theory and methodology, formulation of design statements and specifications, alternative solutions, feasibility considerations, production processes, concurrent engineering, detail system descriptions, and realistic constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact. At the end of the program, students must complete a meaningful, major design experience that focuses on existing engineering professional practices. Course work devoted to drafting does not count as engineering design (Accreditation Board for Engineering and Technology, 1993a). In addition, hands-on laboratory experiences that combine theory and practice must be an integral component of the engineering program. Appropriate computer experiences must be included in the program. Students must demonstrate their ability to apply probability and statistics to engineering problems. Demonstration of written communication competencies is required. Oral communication in English must also be demonstrated. Evidence of an understanding of ethical, social, economic, and safety considerations is required (Accreditation Board for Engineering and Technology, 1993a). "The overall curriculum must provide an integrated educational experience directed toward the development of the ability to apply pertinent knowledge to the identification and solution of practical problems in the designated area of engineering specialization" (Accreditation Board for Engineering and Technology, 1993a, p. 6). Engineering, like engineering technology, identifies additional criteria for different undergraduate programs, depending upon the specialty area. Specialty criteria are provided for aerospace, agricultural, bioengineering, ceramic, chemical, civil, computer, construction, electrical, engineering mechanics, environmental, geological, industrial, manufacturing, materials, mechanical, metallurgical, mining, naval architecture and marine, nuclear, ocean, petroleum, sanitation, and surveying (Accreditation Board for Engineering and Technology, 1993a).

The general advanced (five or more years or master's degree) accreditation criteria provide additional depth in a student's primary engineering discipline, in engineering areas related to the primary discipline, and in business, social, and/or cultural studies related to engineering practices. Advanced study may also emphasize a broad study in construction, manufacturing, engineering management, and/or engineering entrepreneurship (Accreditation Board for Engineering and Technology, 1993a). "The program must include an engineering project or engineering research activity (experimental or analytical) of significant depth requiring innovation and creativity and resulting in a thesis or report that demonstrates both mastery of the subject matter and a high level of written communication skills" (Accreditation Board for Engineering and Technology, 1993a, p. 10).

The ASEE publishes a directory of engineering and engineering technology programs in the United States. A total of 1,442 baccalaureate and 30 master engineering programs were accredited by the EAC/ABET as of December, 1993 (American Society for Engineering Education, 1993b).

Administering Engineering Programs

A common organizational pattern for large programs is for each engineering discipline to be a separate department housed in a school or college of engineering. The five traditional engineering disciplines are civil, mechanical, mining and metallurgical, chemical, and electrical. Some authors would also include military engineering in this list. As previously indicated, the EAC accreditation guidelines have identified criteria for different engineering disciplines. Other disciplines that exist, but have not been identified by the EAC, are architectural, automotive, automatic control, cybernetics, design, fire protection, forestry, genetic, geothermal, hydraulics, optical, petroleum, plasma, plant, plastics, process, production, quality, highway, safety, software, soil, steam, structural, systems, traffic, and transportation.

Some related engineering disciplines may be housed in one department (e.g., metallurgy and materials engineering; naval architecture, marine engineering, and ocean engineering; soil, structural, and architectural engineering; and mechanical and automotive engineering). Some engineering programs may be housed in another college, but their faculty and/or programs are usually assigned to the school or college of engineering. Some examples of this arrangement are agricultural engineering, chemical engineering, and computer engineering. It is also common for most engineering schools or colleges to have multiple departments such as chemical, computer, electrical, mechanical, and materials. These departments, in addition to teaching courses specific to their majors, teach the basic engineering science courses for all related engineering disciplines.

A new trend, especially at the graduate level, is to have an interdisciplinary program within a college of engineering or in cooperation with another college, such as the college of business. One example would be a production, industrial, manufacturing, or engineering management graduate program. The faculty from two or more programs and/or colleges teach the courses, are supervised by a designated coordinator or administrator, and the programs may be located in one facility.

There are common organizational patterns that exist for including engineering technology programs within a school or college of engineering. Some colleges include engineering technology, regardless of the number of programs, as a single department and they have the same status as a department representing an engineering discipline. Other schools or colleges include engineering technology programs within related engineering departments (e.g., department of mechanical engineering and engineering technology). Some universities have a separate unit or division for engineering technology and engineering. Both divisions may be subunits of a school or college of engineering or the engineering technology programs may be housed in a separate college of engineering technology, technology, or other similarly named school. There are usually departments representing specific engineering technology fields or engineering disciplines within each division.

Typical Careers in Engineering

Typical positions engineers hold in industry are closely related to their engineering degree titles: automotive engineer, civil engineer, computer engineer, construction engineer, electrical engineer, industrial engineer, mechanical engineer, nuclear engineer, plant engineer, structural engineer, systems engineer, etc. Research and development units are usually supervised and managed by engineers. Hence, common position titles are research and development manager; manager of a specific research and development division such as chemical, industrial, or computer; chief engineer, associate or assistant chief engineer, or chief engineer of a given project or unit; chief production engineer of a given project or unit; and administrative engineer for a specific division or unit such as design engineering, stress analysis engineering, and process engineering. Engineers may also manage different divisions or units of a company and they hold management positions in such areas as computer-aided design, computer-aided manufacturing, inventory control, manufacturing, production, process design, product design, quality control, systems, and technical sales.

Advanced Degrees, Associations, and Certifications

As previously discussed, engineers can pursue master's and doctor's degrees in engineering or they may pursue a master's degree in business. Engineering master's degrees usually emphasize in-depth knowledge in a specialty, in-depth knowledge in engineering practices and research, and/or engineering education.

There are engineering and/or professional associations related to major engineering fields. Many of the associations are large enough to offer certification programs. The names of some institutes, academies, societies and associations are the following:

Air Pollution Control Association (APCA)
American Academy of Environmental Engineers (AAEE)
American Association of Cost Engineers (AACE)
American Congress on Surveying and Mapping (ACSM)
American Consulting Engineers Council (ACEC)
American Institute of Aeronautics and Astronautics (AIAA)
American Institute of Chemical Engineers (AIChE)
American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME)
Society of Mining Engineers (SME-AIME)
Society of Petroleum Engineers (SPE-AIME)

The Metallurgical Society (TMS-AIME)
American Institute of Plant Engineers (AIPE)
American Nuclear Society (ANS)
American Society for Nondestructive Testing Inc. (ASNT)
American Society of Agricultural Engineers (ASAE)
American Society of Civil Engineers (ASCE)
American Society of Engineering Education (ASEE)
American Society of Gas Engineers (ASGE)
American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
American Society of Metals (ASM)
American Society of Quality Control (ASQC)
American Water Works Association (AWWA)
American Welding Society (AWS)
Association of Computing Machinery (ACM)
Institute of Industrial Engineers (IIE)
International Material Management Society (IMMS)
National Academy of Engineering (NAE)
National Council of Engineer Examiners (NCEE)
National Institute of Ceramic Engineers (NICE)
National Society of Professional Engineers (NSPE)
Society of Allied Weight Engineers (SAWE)
Society of American Military Engineers (SAME)
Society of Automotive Engineers (SAE)
Society of Fire Protection Engineers (SFPE)
Society of Manufacturing Engineers (SME)
Society of Packaging and Handling Engineers (SPHE)
Society of Plastics Engineers, Inc. (SPE)
Society of Women Engineers (SWE)
Standards Engineers Society (SES)
The American Society of Mechanical Engineers (ASME)
The Institute of Electrical and Electronics Engineers (IEEE)
The Minerals, Metals, and Materials Society (TMS)
(Accreditation Board for Engineering and Technology, 1991a; Accreditation Board for Engineering and Technology, 1991b; Kemper, 1982)

There are also engineering honorary societies. The ones that are best known are the following:

Tau Beta Pi—National engineering honorary society.
Sigma Xi—Recognition of noteworthy achievement in research.
Eta Kappa Nu—National electrical engineering honorary society.
Pi Tau Sigma—National mechanical engineering honor society.

Chi Epsilon—National civil engineering honorary society.
Alpha Pi Mu—National industrial engineering society. (Kemper, 1982)

Engineering education in the United States has continued to improve and respond to national, regional, and local needs. Engineering professional associations have evolved and continue to change, as necessary, to provide leadership for engineering education and the profession. "The twin characteristics of adaptability and stability will continue to serve engineering education well" (Grayson, 1993, p. 267).

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CHAPTER 3

Technology and Liberal Education

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The movement to include the study of technology as a part of the liberal arts or general education core at the university level is a logical extension of the philosophy that the study of technology—and its predecessors—should be a part of general education at the middle school and high school levels. The movement at the college level, although begun several decades ago, was not led by leaders in industrial arts or industrial technology. This chapter will provide a rationale for the study of technology as part of liberal education, briefly trace the history of the movement, identify the barriers to the inclusion of technology in the liberal arts core, and discuss the implications of this movement for technology education.

DEFINITIONS

Certain key words in this chapter are used frequently in academic circles, although they are rarely defined. Several of the words are used interchangeably, which only makes their use more confusing. The definitions provided in the following paragraphs of this section will be used throughout this chapter.

Chapter 1 defined technology as "a body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment" (Wright & Lauda, 1993, p. 3). One may conclude from this definition that technology is primarily a process and artifacts which, when viewed as the core of technology, become the product of technology, i.e., the result of applying technology. Chapter 1 also defines technology education as "an educational program that assists people [to] develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (Wright & Lauda, p. 4).

In the medieval university, liberal arts referred to a core of disciplines considered essential to all educated men. (Higher education was predominantly a male privilege in that period.) These disciplines, which included rhetoric, logic, grammar (the trivium), music, arithmetic, geometry, and astronomy (the quadrivium), were based on the Greek concept of the moral and "free" man, a man who could think clearly and logically, speak effectively, read analytically, have knowledge of the world and human nature, and know the ways in which the universe operated (Mason, 1972, p. 25). This ideal can be traced to Plato's *Republic* (Bloom, 1968) and other writings in which he discussed the education for the governors of the state. Liberal arts education was originally never intended for anyone but the wealthy elite.

The Industrial Revolution and a democratic form of government have created a large middle class and a commitment to educate everyone. The content of the liberal arts has expanded to include history, more natural sciences, and the social sciences, but the purposes have not changed appreciably. Griswold (1962), in discussing the role of the liberal arts in the 20th Century, wrote the following:

> The purpose of liberal arts is not to teach business men business, or grammarians grammar, or college students Greek and Latin. . . . It is to awaken and develop the intellectual and spiritual power in the individual before he enters upon his chosen career, so that he may bring to that career the greatest possible assets of intelligence, resourcefulness, judgment, and character. (p. 13)

Not only would one bring these assets to one's career, but one would also apply them in being an involved and responsible citizen.

Liberal education refers to the education that one receives from studying the liberal arts or the general education requirements. In simplistic terms, the goal is to liberate the student from ignorance and prejudice. Bloom (1987) stated the purpose of liberal education very simply: "A good program of liberal education feeds the student's love of truth and passion to live a good life" (p. 345). Kranzberg (1991) asserted the following:

> The purpose of an education [liberal arts and education in general] is not only to train students for a career, but also to challenge them to think about the meaning and purpose of life, their role in both the cosmic and human scheme of things, and their relationship toward their immediate neighbors and toward the larger global society. (p. 239)

The terms liberal education, liberal arts education, and general education are often used interchangeably. While some educators argue for a general education core designed to pass on a common culture (Hirsch, 1988), others are equally passionate about requiring multicultural and feminist courses to help students become more sensitive to cultural and gender differences (Alvis, 1993).

Literacy is defined as having the knowledge and skills to function successfully within a given society at a given time. This definition recognizes that literacy may require skills other than the ability to read and write (Merriam-Webster, 1990). It also recognizes that literacy is site and time specific. Not only are the necessary skills for succeeding in America different from those needed by a Somalian, but the core of common knowledge one needs to function is also quite different (Hirsch, 1988).

Literacy is also in a state of flux. For example, with the advent of the personal computer, new elements are being added to the common core of competencies. One may argue, however, that computer operation is not required to function in society, although it is required in many occupations. This insight identifies another characteristic of literacy, which is that it exists at different levels and is situation specific (Todd, 1991).

In the 40th Yearbook of the Council on Technology Teacher Education, Dyrenfurth and Kozak (1991) defined technological literacy as follows:

> A multi-dimensional term that necessarily includes *the ability to use* technology (practical dimension), the ability to understand the issues raised by our use of technology (civic dimension), and the appreciation for the significance of technology (cultural dimension). (p. 7)

After reviewing the definition of literacy, one could conclude that technological literacy is subsumed by the literacy definition and need not be separated. While such an interpretation has merit, isolating technological literacy is helpful for the same reason that isolating scientific literacy or any other component part of general literacy in that it permits a discussion of what competencies and knowledges are essential in that segment of literacy needs.

HISTORICAL ANTECEDENTS[1]

Teaching technology as part of the liberal arts or general education core at the baccalaureate level is of recent interest in the technology education

[1]Portions of this section are excerpted from Wiens, A. E. (1987). *Teaching technology as a liberal art.* Journal of Industrial Teacher Education, *25*(1), 7–16. Used with permission.

profession. While some industrial arts courses in years past were included as part of the distribution requirements at a few colleges and universities, the move towards technology as a discipline base in our profession provided a slogan—technological literacy for all—which was more attractive and defensible for general education than was the industrial base that had preceded it. Although our profession was not yet promoting technology education 15 years ago, programs and curricula to address technological literacy have been in existence for several decades. This movement has gained momentum recently at all levels of education. This section of the chapter traces the primary programs that have led to the present status of technological literacy courses as part of the liberal arts.

Secondary School Programs

One of the forerunners of the current programs for technological literacy was an engineering concepts course designed for juniors and seniors in high school by the Engineering Concepts Curriculum Project (ECCP) (Liao & Piel, 1970). The project was initiated around 1965 and had 300 high schools across the nation participating by 1970. The rationale behind the program was essentially a recognition that people live in a very complex technological world, and a technologically literate citizenry is needed to make the best decisions. The course that developed—"The Man-Made World" (TMMW)—was designed for average ability, college-bound high school students who were not planning to enter careers in science or engineering. It was "designed to familiarize students with certain concepts which pervade modern technology" (p. 2). While the overall objective of the project was technological literacy, the project staff was also concerned that "students understand that constant interaction occurs among science, technology, and society; that any major decisions or changes in one must affect the other two" (p. 3). It is also noteworthy that three of the directors of the ECCP were engineering professors at the State University of New York at Stony Brook. Stony Brook later became the center for the New Liberal Arts program, which played a major role in supporting technology literacy courses at the baccalaureate level.

Current Status of Public School Technological Literacy Programs

The movement to teach technological literacy at the K–12 levels is currently gaining its greatest momentum through the science, technology, and society (STS) program. A study of public education programs reported at the 1993 National Association for Science, Technology and Society

(NASTS) conference confirmed this fact. Researchers had contacted the state departments of education in all 50 states to gather information regarding the implementation of STS and STS type education (Kumar & Berlin, 1993). The findings revealed that 10 states required STS education and all but 3 of the remaining 40 states recommend and/or encourage the inclusion of STS type education. The study also found that 25 states reported a total of 3,381 school districts (22% nationwide) that have now implemented STS education. The implementation of these programs is primarily in the hands of science educators.

There is not agreement, however, that the teaching of technology should be the responsibility of science educators. Tanner (1990) believes that social studies should serve as the integrating center of the curriculum when technological issues are being addressed. Others, such as Ost (1985) believe that mathematics and science jointly have the responsibility for teaching about technology. Project 2061, however, a benchmarking program by the American Association for the Advancement of Science (1992), clearly defined scientific literacy as embracing "literacy in all the sciences, mathematics, and technology" (p. 5). Roy (1990), an STS leader, distinguishes clearly between science and technology, and believes that "teaching technology and about technology is important for all citizens, while science is an equally important addition for a small (10–15%) subset" (p. 11).

Describing a typical course is somewhat difficult, given the variety of approaches used by the STS educators. One example, however, as shown in Figure 3–1, may be instructive. Every module developed by the New York Science, Technology, and Society Education Project (NYS_2TEP) begins with "an experience which raises a question, problem, or issue to be explored and ends with a decision and action or product" (Roeder, 1992, p. 5). The graphic model that accompanies each module illustrates three equally important approaches to exploring the problem or issue. These approaches are scientific inquiry, technological design, and values exploration. This three-pronged approach provides the broad perspective that is missing in a single disciplinary approach. By focusing on community problems, this process prepares young people for responsible citizenship. Some of the topics addressed by these modules are solid waste, using earth's resources, getting there (exploration of different modes of transportation), and drinkable water (Roeder, 1992).

Technology as Liberal Arts at the College Level

About the same time that "The Man-Made World" was being introduced at the high school level, a new interest area was being spawned at the college level. In most cases, these science, technology, and society programs or

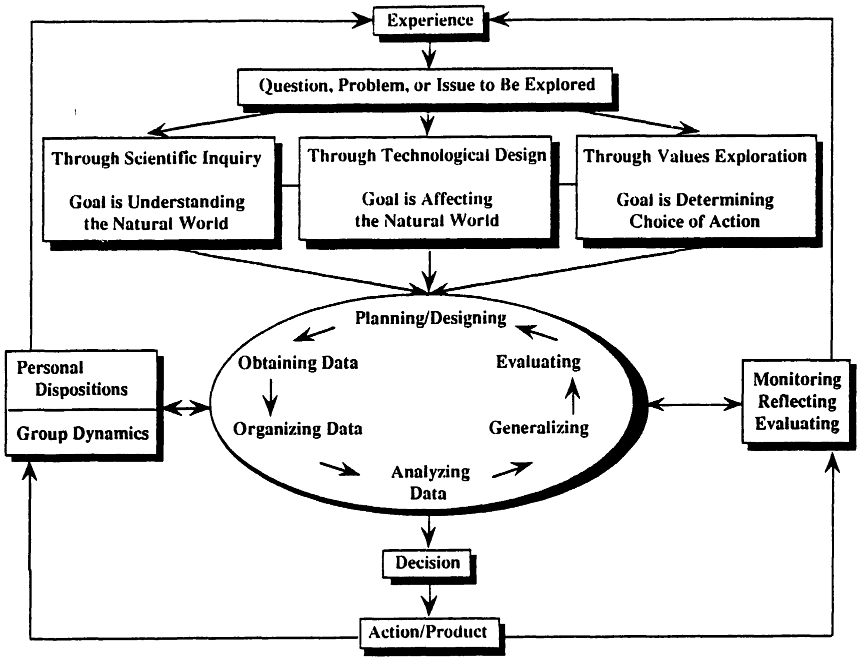

Figure 3-1: The NYS_2TEP Instructional Model for Middle-Level Science (Source: New York Science, Technology, and Society Education Project as shown in Roeder, J. L. [1992, Fall], p. 5.)

courses were a direct result of the disenchantment of young people with authority, power, and technology during the Vietnam War era. The goal of many of these courses was not initially technological literacy, but rather the examination of the negative impacts of technology. Rachel Carson's *Silent Spring* (1962), John Kenneth Galbraith's *The New Industrial State* (1967), Vance Packard's *The Hidden Persuaders* (1957), Ralph Nader's *Unsafe at Any Speed* (1965), Jacques Ellul's *The Technological Society* (translation 1964), and Lewis Mumford's double volume set *The Myth of the Machine* (1967 & 1970) are examples of the literature that described ways by which society and/or the environment were being sacrificed in the name of technological progress. Academically, much of the social awareness education that resulted was directed toward engineering and science students. Liberal arts students were equally attracted to the issues addressed by these courses, and the content of the second generation STS courses focused more on the way by which technology and science are shaped by societal values, which in turn are shaped by technology and science. Some of the programs did, however, provide a more positive atmosphere for studying the nature of technology.

The interest in technological literacy as a primary goal of STS courses is a recent development, having become a major theme since 1980. Despite this thrust, however, the syllabi continue to show considerable diversity. Some instructors still teach about technology and technological impacts, as contrasted to teaching the use of the tools of the technologist in problem solving, which is a stated goal of STS courses (Cutcliffe, 1983).

Rustum Roy (Krieger, 1987), Director of Pennsylvania State's STS program, presented his view of the role of STS programs when he stated the following:

> Effective citizenship demands a new kind of literacy in technology and science that cannot be met by adding a course in algebra. STS is a wholly new approach to making citizens more concerned about our technological culture, more comfortable in it and more in control of their own lives and decisions. (p. 26)

The National STS Network (n.d.) views STS as "absolutely essential CITIZEN EDUCATION" which, at the college/university level, is the "absolutely indispensable core of general education" (p. 1). In 1990 the National Science Teachers Association's (NSTA) Board of Directors unanimously approved a position paper that endorsed STS education. The paper stated the following:

> STS means focusing upon current issues and attempts at their resolution as the best way of preparing students for current and future citizenship roles. . . . the major goal of STS efforts is the production of scientifically and technologically literate persons after 13 years of involvement with science in school. (National Science Teachers Association, 1991, pp. 16, 17)

A lack of distinction between scientific and technological literacies is quite common, especially by educators who are not in technology fields. In a curriculum guide for science and technology that was developed as a result of a summer institute funded by the National Endowment for the Humanities, the distinction is made between the two literacies. It is interesting to note that the authors of the guide were predominantly from the humanities (Fuller & Raman, 1991). In the context of this group, STS courses were seen as improving scientific literacy, with no mention of technological literacy as a separate entity (Mills, Gross, Hahn, Rice, & Wozniuk, 1991). Increasingly, however, scientific literacy is being defined as including technological manipulation and problem solving.

The fact that not many of the STS programs have become full-blown programs should not come as a surprise. While the 1970s were a good growth period, colleges and universities in the 1980s witnessed a decline in the number of high school seniors from which to draw. This situation, coupled with large inflation figures, put economic pressure on institutions of higher education to cut back, not expand. Yet, several institutions do have sizable programs. The National STS Network (n.d.) has made the general claim that "thousands" of colleges offer from 1 to 30 courses and that 100 formalized programs exist, but no research was cited to substantiate the claims. Some examples of programs include the Program in Values, Technology, Science and Society at Stanford University; the Department of Technology and Society at the State University of New York (SUNY) at Stony Brook, where more than 70% of the liberal arts graduates take at least one elective course in the department; the Program in Science, Technology and Society at Massachusetts Institute of Technology (MIT); the Man, Technology, and Society Program at St. Louis University; and the Science, Technology and Society Program at Lehigh University.

In a 1985 survey of general education technology courses conducted by the Council of Independent Colleges (CIC), responses were received from 195 of its 718 institutions. The 343 courses submitted were reduced to those that coupled the liberal arts and technology, had a scientific basis, and also dealt with technology as a social process (Lisensky, 1985). These parameters were met by only 99 courses. The CIC reported that 105 of the course syllabi were rejected because they were one-dimensional in scope, usually determined by the disciplinary orientation of the instructor. Science faculty usually ignored the nature and role of technology in society; social science and humanities faculty usually paid too little attention to either the technological or scientific component.

Another observation from the results of the survey was that many educators equated technology with the computer. One hundred thirty-nine of the 343 course syllabi dealt with computers, most of which did not treat the computer as a technological artifact. Computer literacy is "overshadowing" the "more fundamental issue of technological literacy," stated Robert Lisensky, former Executive Director of the CIC (Lisensky, 1985, p. 18).

The New Liberal Arts

Another significant event in the teaching of technological literacy occurred in 1980, when the Alfred P. Sloan Foundation began diverting some of its educational funding from graduate to undergraduate education to improve analytical skills and technological literacy in general education (White, 1981). Leaders in the New Liberal Arts (NLA), the name adopted by the Alfred P. Sloan Foundation, distinguished clearly between technology and science, noting that science describes what is in the natural world while technology intervenes to change the human environment. As the program developed, the focus became a triad: applied mathematics, computer literacy, and technological literacy. White (1981) summarized the focus of the program:

> The purpose [of the Alfred P. Sloan Foundation] has not changed: it is to turn out civilized adults, a few of whom will inevitably become applied mathematicians and technologists and computer scientists and philosophers and historians, most of whom will not. But no adult is truly civilized unless he is acquainted with the civilization of which he is a member, and the liberal arts curriculum of fifty years ago no longer provides that acquaintance. (p. 11)

The New Liberal Arts program referred to the engineering approach to problem solving as the technology that a technologically literate person should be able to understand and use. In addition, the NLA adopted the principle that the concepts of technology can be taught regardless of the specific technology chosen, and that a study of technology must be interdisciplinary in approach. This broad view resulted in a smorgasbord of courses.

Over the course of the New Liberal Arts program (1983–1992), the Alfred P. Sloan Foundation awarded grants to 24 liberal arts colleges, 112 historically black institutions in the Southeast, and 15 universities. The grants supported faculty in developing new courses and modifying existing ones within the liberal arts undergraduate programs (Truxal & Visich, 1992).

The original intent of the Alfred P. Sloan Foundation program was not to displace courses in the existing curricula, nor to introduce new and separate programs, but rather to "suffuse and enrich the present liberal arts curriculum" with quantitative and technological material (Koerner, 1985, p. 4). In this manner, no student could escape technology and quantitative reasoning. Koerner discovered, however, that most institutions had taken the path least threatening to the existing (and entrenched) disciplines by adding separate courses. The Alfred P. Sloan Foundation discontinued its support for the New Liberal Arts programs in 1992, disappointed that the study of technology had not permeated the other disciplines and courses as originally hoped. Although hundreds of new courses have been developed in the colleges and universities that have benefited from the Alfred P. Sloan Foundation's funds, few institutions incorporated the study of technology within required core courses.

The Status of Technology Education's Role in the Liberal Arts

The previous section of this chapter included descriptions of the major movements providing technology courses as a part of liberal education. The technology education profession was not involved in any of the movements discussed. In part, this is because fewer than 25% of four-year colleges and universities have technology education departments or equivalents. The concept that the study of technology ought to be a part of an undergraduate education, however, has received increasing support from within the technology education profession during the past decade. Evidence of this claim is apparent by the activity in this field at the International Technology Education Association (ITEA) conferences, the establishment of a Task Force by ITEA to address the concept, and the continued presence of technology educators at such professional conferences as the National Association for Science, Technology and Society's annual Technological Literacy Conferences.

In an unpublished study, a survey was conducted in 1989 by John T. Fecik of the University of Northern Iowa and A. Emerson Wiens of Illinois State University to ascertain the involvement of technology or industrial technology education departments in offering technology courses for general education credit. Answers to a number of research questions were sought in regard to student makeup, curriculum content and methods, enrollments, listing of the course, and other variables. To obtain the answers to these questions and to provide base line data for future studies, a survey instrument was sent to all department chairs listed in the 1988–89 *Industrial Teacher Education Directory*. This list represented 251 institutions. Usable responses were received from 140 institutions, representing a 56% return.

Respondents from only 44 of the 140 institutions (31.4%) indicated they currently have technology courses that are accepted for general education credit. This is a slight drop from the 38.6% of the institutions that claimed to be offering such courses in a study completed by Blankenbaker (1980) nearly 10 years earlier. With over 40% of the institutions not responding in this study, however, the 7.2% difference may not provide a clear indication of a trend.

Of the 96 respondents who indicated they did not have such a course, 40 stated they were "definitely" (4) or "maybe" (36) adding a general education technology (GET) course in the next three years. The responses were analyzed according to whether the GET courses were standard departmental offerings or specially designed courses. The respondents identified 60 courses (74%) as being specifically designed for general education credit, while only 21 (26%) were standard departmental courses. Only nine of the standard courses were of the more traditional materials and processes type, such as metal technology, electricity, and automotive fundamentals (seven of these were in one institution). Similarly, 55% of the institutions offered only specially designed GET courses compared to 25% that offered only standard departmental courses for general studies credit.

In order to compare these data with the data reported by Blankenbaker (1980), the courses were further categorized according to whether they represented a technological base or an industrial base. A very definite shift towards a technological base occurred in the decade between the two studies, with 52% of the courses in Blankenbaker's study based on technology and 83% of the courses in the Fecik and Wiens study so categorized. In the specially designed courses, there is a growing emphasis on interdisciplinary

Theme	Course Titles[1]
General Introduction	Perspectives in Technology; Survey of Technology; Basic American Industries; Explorations in Technology; Understanding Technology; Technology Literacy; Technology of Agriculture and Industry; Technological Systems
Society/Social Reference	Society and Technology (or vice versa)(6) Technology: Impact on Society (2) Modern Technology and Society Technology in Society Impacts of Technology Modern Technology and Civilization Technology and Social Relevance Man, Society, and Technology Technology, Society, and the Individual Application of Technology to Social Problems
History Reference	History of Technology (2) American Technology Technology in Western Civilization Evolution of Technology
Humanities: ethics, philosophy, values	Studies in Technology and Philosophy Ethical Problems in Technology Introduction to Humanities, Science & Technology
Science/Environment	Science and Technology in Western Culture Science and Technology in the Modern World Science, Technology, and People Man, Technology and Environment
Culture Reference	Catalyst of Culture Technology and Cultural Relevance
Future Orientation	Future of Technology Future of Work Technology Assessment

[1]Since some institutions listed more than one course, the titles do not necessarily represent different institutions.

Table 3-1: Titles of specially designed technology courses for general education credit.

content. Technological impacts, history, and future orientation have received more emphasis as the profession has moved towards the technology base.

An overview of the course titles in Table 3–1 suggests that the typical educational track followed by most university industrial/technology education programs provides inadequate preparation to teach such courses. The reported preparation of the teachers indicated that they obtain most of their background by means other than standard catalog courses.

Blankenbaker (1980, p. 38) reported that general education technology courses "tend to emphasize laboratory work," a finding that was reversed in the Fecik and Wiens study. No laboratory activities were included at all in GET courses in half of the reporting institutions. The laboratory activity, when included in courses, occupied 25% or less of class time in over 60% of the cases reported. Eleven of the 41 respondents identified community problems as a focus. In these courses, the community becomes the laboratory.

Blankenbaker (1980) found that 84% of the students in the courses in his survey were male, with over 70% in technology, science, or applied majors. In the Fecik and Wiens study, 59% of the respondents considered their students to be a typical cross-section of students and in only 30% of the institutions were the students mostly male. These data indicate that general studies technology courses, although being taken by more typical students than 10 years earlier, still have not been fully accepted by all students or, perhaps, by all academic advisors. In over 50% of the schools that have such courses, according to the respondents, fewer than 10% of the students will have taken a technology course by graduation.

APPROACHES

The Interdisciplinary Focus

The American Association for the Advancement of Science (1990) describes a liberal education as follows: "The essence of a liberal education arises from the synthesis of the various domains of knowledge" (p. 51). Students, however, typically spend their whole educational careers taking courses designed to expose them to one discipline at a time (history and philosophy would be the exceptions since they are integrative by design). Few baccalaureate programs have integrative, interdisciplinary courses that are broader than career track capstones, and the interdisciplinary courses that do exist are typically taken after 15 years of segregating knowledge.

In contrast to other disciplines, technology cannot be studied in isolation. Technology is a social process that occurs within a social, environmental, economic, and political milieu. This interdisciplinary nature is understood by the STS community (Truxal, 1985), and is included, at least to some degree, in most definitions by technology educators (DeVore, 1987; Hughes, 1986; Loepp, 1986). In the definition of technology education in the first section of this chapter, the interdisciplinary nature of technology is apparently assumed and not stated (Wright & Lauda, 1993). Dyrenfurth and Kozak's (1991) definition of technological literacy refers to the "ability to understand the issues raised by our use of technology" (p. 7), and the International Technology Education Association Advisory Council (International Technology Education Association, 1986), in discussing technological literacy, "felt that not only should students study the benefits of technology, but also the 'down side' of technology—the possible environmental and cultural consequences" (p. 5). These definitions imply the interaction of the technology/society interface after technology is developed, but do not refer to the cultural mix that gives birth to technology and in which technology is practiced. Technology does not become interdisciplinary after negative consequences of its use are discovered; it is interdisciplinary from its inception.

New Course Development

As the Fecik and Wiens survey indicated, shifts have occurred since 1980 in the content and methods of technology courses taught by technologists for non-technologists. The courses today are much more like those taught in STS programs. They are more likely to be taken by a typical cross section of students, and the courses are less likely to have laboratory components.

Typically, courses in technology education and industrial technology at the baccalaureate level are part of technical or teacher education programs and are not intended as general education. In order to appeal to general education curriculum committees, new courses have been designed that are truly liberal education by objective and in content. These courses must utilize teaching materials that are designed for use with students for whom the course is their only exposure to a systematic study of technology.

In a society where the knowledge is doubling every four years, what should be taught about technology that will last? That question was addressed by the ITEA Task Force on Technology Education as Liberal Education (1993) when it designed a course to teach technology to non-technologists. The course was organized around four themes—history, systems, impacts, and futures—that provide a framework for understanding technology in a way that should not become dated. Studying the history of technology helps students understand the social context in which technology is practiced and out of which different technologies were born. It also assists students in recognizing that studying previously solved problems can assist us in addressing problems in the present and future.

The systems paradigm is an important concept to comprehending technology, since all technology uses systems and develops within systems. Just as a carburetor has various systems within it—the idle system, acceleration system, high-speed system, economizer, etc.—the carburetor is itself a part of the fuel system. This is part of the automobile, which is part of the transportation system, which in turn is supported by many subsystems including the road and highway system, the service and repair system, and more. The instructor and student must remember that these systems are not strictly linear systems occurring in a vacuum. Technology is the direct outgrowth of a social/cultural ethos that is unique to a people in a given place and at a specific time in history.

The concept of impacts reminds students that the technology/society interface is interactive, and that delayed and unintended consequences of using technology are often overlooked or ignored, but are usually of immense importance. Chlorofluorocarbons (CFCs) were considered the perfect refrigerants when first invented. Not until years later was their destruction to the ozone layer detected. In like manner, few people foresaw the impact that the automobile would have on society.

The primary way by which the future will change is through technology. Hence, studying futuring techniques and projecting possible futures is a useful way for students to recognize the importance of current decisions regarding technology and the necessity of regulatory bodies. A criticism that has often been expressed is that these new courses are too frequently void of laboratory work, that they are studies *about* technology, not *in* technology. This is a legitimate concern that should be taken seriously by every educator developing a technology course. Truxal (1986) addressed this concern when giving his views on the content of STS courses:

> Here we must teach the basic principles of how a device works, and its capabilities and limitations. In addition, historical development should be considered: the scientific, technological, and cultural settings from which the device evolved, and its impact, both positive and negative (the technological assessment). (p. 17)

Many technology educators would prefer to arrange content around the organizers of production, communication, transportation, and perhaps, biotechnology. This may be the best way to introduce middle school students to technology. These organizers and the four described above—i.e., history, systems, impacts, and futures—are not incompatible, since the history of technology development and the concepts of systems, impacts, and futures can be addressed within each of the technological areas. Wright (1992) suggests that the model developed around these organizers (Hales & Snyder, n.d.) is basically a production model. He recommends a broader model that addresses the technological actions of developing, producing, using, and assessing as unique subsystems. Regardless of the organizers used, students should develop the self-confidence to believe that they can use, understand, and make accurate judgments about virtually any technology if they put their minds to it.

What does it mean to use technology? All people use technology because they all use the telephone, drive a car, and set their thermostats. This is not the meaning most educators have in mind when they write "be able to use technology." The Task Force authors (ITEA Task Force on Technology Education as Liberal Education, 1993) struggled with the assignment of having to plan a single course for college students with non-technology majors, since most non-technologists at the college level would take only one technology course if not required to take more. The authors felt that the cognitive understanding and affective involvement of students, coupled with problem solving and a minimum of activities that require psychomotor skills, was an effective way to teach such a course.

Donald R. Daugs (1992), NASTS Position Papers' Committee Chair, when addressing "The Niche for STS," listed several guiding principles that identify STS as a process. One of the principles states that depth in a few topics and personal relevance are of greater value than "encyclopedic coverage" (p. 3). Students are not being short-changed if the course does not cover the whole technology area or areas. Rather, they are missing opportunities for understanding if, in the attempt to be comprehensive, the content becomes superficial. Courses at the baccalaureate level should not be a copy of secondary courses, but should reflect the fact that college students are more mature and have an expanded interdisciplinary knowledge base. College courses in technology should challenge the student intellectually, and the in-depth technology course is an appropriate way to do this. A focused course in medical imaging technologies or high speed trains could serve as well as, if not better than, a survey course based on the Jackson's Mill curriculum model (Hales & Snyder, n.d.).

Faculty Development Techniques

The Fecik and Wiens study found that a majority of technology education faculty who are teaching technology as liberal arts courses received their preparation to teach such courses outside the standard teacher preparation structure. The study clearly shows that for current teachers, in-service education, appropriate journals, memberships in other professional organizations, and attendance at related conferences would be immensely useful. While space does not permit a complete bibliography of resources, a listing of several periodicals that may be useful in broadening one's views of technology in society are noted at the end of the chapter.

What should be the role of our professional organizations in faculty development? First, professional organizations should serve as a forum for new ideas and a means for members to evaluate the discipline in light of new information. A professional organization can stimulate discussion internally in several ways. A section-level group could be formed in the International Technology Education Association and/or the Technology Education Section of the American Vocational Association to focus on teaching technology as part of college level general education. These sections could become liaisons between STS and the technology education programs.

Professional organizations can promote interdisciplinary dialogue by inviting leaders from STS or similar programs to be featured speakers or special interest session presenters at conventions. Professional organizations can also sponsor or cosponsor symposia including persons from technology education and STS programs. The ITEA has already cosponsored one meeting with the STS group in February 1987. Consortia need to be formed, which should include professional associations, corporations, and government agencies with similar goals of promoting technology education at the college level. This is already a stated goal in the International Technology Education Association's (n.d.) Strategic Plan for 1993. Such cooperation needs to continue in order to improve technology education at all educational levels. Professional journals can solicit manuscripts from persons outside technology education to introduce the philosophy, methodology, and contents of liberal education technology courses from their perspectives.

Technology teacher education programs must make curriculum development and the teaching of technological literacy a priority. Most of the teaching candidates will not teach at the baccalaureate level. A majority of the public school students they will be teaching, however, will become citizens without the benefit of a college education. If we are to have a technologically informed and involved citizenry, public school teachers must make technological literacy a goal.

General education requirements for most teacher education programs require a mix of courses that could form the structure for addressing the interdisciplinary aspects of technology. Courses in the areas of sociology, ethics, psychology, physical science, environmental science, mathematics and economics would provide a well-rounded background for teaching technology. Why these courses?

1. Sociology is needed to provide an understanding of how human beings function in society, and of the development, nature, and function of social institutions.
2. Ethics provides a framework for addressing technological decisions, since these decisions are often value laden; it provides a forum for discussing selfish interests versus social good.
3. Psychology is needed to provide a background for understanding the development and function of the mind and to study the determinants of thought and behavior.
4. Physical science and mathematics are needed to help the student understand the dependent/interdependent relationship between science and technology, and to develop competency in the use of the basic quantitative and scientific tools used by engineers.
5. Environmental science is needed to help the student understand the dimensions of the human impact on the environment via technology, and to examine appropriate technology solutions to environmental problems.
6. Economics is needed to assist the student in understanding the most powerful social institution in developed countries, since all technological decisions have economic dimensions.

A minimum of one course would still be needed to help students pull these strands of knowledge together, and to understand the social milieu out of which technology develops, i.e., how technology affects society and how society affects technology. Although the primary purpose of a technology teacher education program is to prepare teachers for the secondary schools, this type of program would also be an excellent foundation for those students who go on to graduate school and have the opportunity to teach a technology course for non-technologists at the undergraduate level. Graduate programs in technology education should also encourage students to integrate interdisciplinary knowledge around technology.

Student Development Techniques

Many students place technology, science, and mathematics in the same general category, in that they find them all difficult to comprehend. A primary goal of the technology educator is to break down the fear of technology by studying technologies that are of interest to students and by helping them to conquer their fears by understanding how these technologies work. Having the ability and the self-confidence to succeed in understanding a technological artifact empowers the student and gives that student a feeling of control and independence. To gain this empowerment, students need not become proficient in carpentry, electrical wiring, welding, and all the other useful skills. Students do need to discover that they are capable of solving technological problems and of performing technological tasks if they take the time to study the tasks. Teaching and learning technology should be enjoyable, since it focuses on that which we all use and about which most of us are curious. Many students also need to develop basic technological skills to prepare them for the world of work.

CHALLENGES FOR TECHNOLOGY EDUCATION

This section addresses several challenges for the technology education profession. Until the profession resolves these challenges, its effectiveness as a leader in designing and promoting technology courses as part of the liberal education core will be compromised. The fact that professors in technology have generated some exciting, problem-centered, interdisciplinary technology courses for non-technologists is more a tribute to these individuals in technology education than to any deliberate attempt of the profession to prepare its educators to do it.

1. The first challenge that needs to be addressed is the challenge of accepting a leadership role in developing technological literacy courses as a part of liberal education.
2. If technology education makes the commitment to provide such leadership, the second challenge is that of defining technological literacy in terms of the skills and knowledge needed by citizens and workers today and in the future.
3. The third challenge is closely related to the second, that of identifying the tools of the technologist. There is apparent disagreement between technology educators and the STS movement regarding the essential tools that should be part of a technological literacy course.
4. The fourth challenge is also closely related to the second, that of identifying the interdisciplinary focus of technological literacy courses in liberal education.

Acceptance of a Role

Not all educators believe that technology educators should have the central responsibility for teaching about technology in the secondary schools. The National Science Board Commission (Conference on Goals, 1983) stated that appropriate instruction in science applications and technology integrated into the science curriculum would enhance the teaching of technology literacy. This is also apparent in the National Science Teachers Association's (1991) endorsement of the STS approach and the assumption that science educators should teach it.

Neither do all technology educators at the college level assume that faculty from technology education are capable of developing and teaching such courses. This was apparent by several comments made at the 1992 ITEA Conference. When a proposed technology as liberal arts course was presented, several technology educators expressed their views that the social, environmental, and ethical issues of technology should be left to the sociologist, the ethicist, and the environmentalist. The following letter was sent to all who attended the presentation as a response to those comments:

> Several of you noted that a liberal arts approach to teaching technology requires an interdisciplinary approach involving liberal arts teachers. I think the Task Force members would agree with me that a team-taught course with the right people is preferable to a solo-taught course, but in many institutions, team-teaching is not a possibility or the right mix of people does not exist. Does that mean that "technology as liberal arts" is to be left only to those who are liberal arts educators? My answer is an emphatic "NO"! Just as many technology educators, especially industrial technology educators, lack the background and the interest in teaching technology as liberal studies, so do many of the liberal arts faculty lack the interest, knowledge, and *experience* with technology to provide a balanced picture in such a course. This means that we technology educators will have a reeducating process to consider for those of us who have forgotten the liberal arts we took in college or who went through a baccalaureate program that required little liberal arts.
>
> At the liberal arts college where I taught for 23 years . . . I had the opportunity to team-teach courses of this type, once with a sociologist, once with a physicist, and once with a peace studies professor. The physics professor was preoccupied with teaching vectors and the laws of physics with little interest in applications, the sociologist was anti-technology and not at all objective about the benefits of technology (despite the fact that he was a Ham operator . . .), and the peace

> studies professor was particularly focused on the international dimensions of energy consumption and nuclear energy.
>
> The point that I am trying to make here is that we all bring our own biases to a given course. It is not that the perspectives represented by the three professors were wrong, it is just that each perspective is narrow, just as our own teaching and perspective is often so technically oriented, so hardware oriented, that we do not adequately address the sociological, environmental, and ethical dimensions of technology. Nor do I want to imply that all liberal arts professors provide a narrow, unbalanced perspective, since I have heard some superb presentations at the National Association for Science, Technology and Society annual conventions over the past four years. But here, too, I have heard some science teachers who see technology strictly as applied science and nothing more, and ethicists who are mostly concerned with the ethical dimension, etc.
>
> We really need to ask: what unique understandings or perspectives do we, can we, as technology educators bring to the teaching of technology as liberal arts? Can we help provide a balanced approach to a liberal arts course? We can obviously learn from those teaching these courses who approach them from different disciplines. This is why we need to become more involved with STS, NSF and other organizations. (Wiens, 1992)

Technology educators do have a perspective on technology that is often different from that of educators from other disciplines, one that is based on the familiarity of practice. This perspective is important and often underrepresented by other educators. The technology education profession has an important role to play in influencing the content of liberal education technology courses and providing leadership in their development, acceptance, and instruction. Technology educators, however, must also take into consideration that another field, specifically engineering, routinely addresses technological problems and views literacy needs somewhat differently.

Technological Literacy Versus Technology as a Curriculum Organizer

Just how will the content and methodology of a course differ if it is organized as a literacy course as opposed to being organized simply on the subject matter's knowledge base? The answer depends in large part on the definition of literacy used. Dyrenfurth and Kozak's (1991) definition in the first section of this chapter states that technological literacy is more than a product of the cognitive domain, that the technologically literate person must be able to use the tools and materials of the literacy. Most definitions of literacy maintain that the literate person demonstrates three aspects: (a) an understanding of the subject (a cognitive base), (b) an appreciation for the role of the subject in society, and (c) the ability to use the subject. Using language as an example, literacy means that we understand the basic rules of grammar and rhetoric, appreciate its function in helping us think and remember the past, and must be able to speak and write the language. When persons are traveling in another country, they discover quickly how literate they really are, based on their ability to use that country's language. The primary difference, then, between a course designed to provide literacy and one that is not, is the mandate that the student shall leave the course being proficient—i.e., having specific knowledge about technology and having certain technological skills—at some prescribed functional level. The skills would be those deemed necessary for a person to function successfully in our current society.

A concern expressed by Waetjen (1993) must be noted before leaving this discussion on technological literacy. He stated "that until technology education has defined its intellectual domain, it is fruitless to try to describe a technologically literate person" (p. 8). He believes that the profession would be much better off if much of the thought and energy consumed in promoting technological literacy would have been spent defining technology education as an academic discipline. The discipline, if indeed it is a discipline, does suffer from a lack of definition and consensus on what the body of knowledge is or ought to be. The goal of technological literacy, however, must go hand in hand with defining the intellectual domain of technology studies. Liao (1991) described the knowledge base used to develop courses to achieve technological literacy in the Department of Technology and Society at SUNY-Stony Brook as consisting of five areas:

- Technological Systems and Engineering Concepts
- Application of Science Concepts
- Applied Math: Quantitative Methods
- How Individuals Interface with Technology
- How Technological Systems Interact with Other Systems (p. 2)

Pucel (1992) also tied the knowledge base of technology to technological literacy when he answered his own question regarding the content of technology studies. He stated, "Technologically literate people have two primary characteristics: 1) they have developed a common sense knowledge of technology, and 2) they understand the method through which technology evolves to satisfy human needs" (p. 8). Common sense knowledge is that which is learned through living and experiences that provide contextual information within which one interprets and manipulates things (Pucel, 1992). Obviously, the curriculum needs to be designed to help the student develop a common sense knowledge of technology, with the ability to use the tools of the technologist.

Tools of the Technologist for a Liberally Educated Person

Technology educators are often preoccupied with certain technology fields, such as communication, production, biotechnology, and transportation. If the goal of a course, however, is to help students understand how technology works and to do technology, the curriculum content possibilities are vast. Just as one can learn how science is done by studying one area of science in more depth, one can also learn how technology and technologists work by examining one subject in depth. The STS programs feature many in-depth courses that provide opportunities for students to solve problems using technology, and/or to solve technological problems.

While most technology educators seem to agree that the student should be able to use technology, they do not agree on what skills and knowledge the student should have. An important component in the New Liberal Arts definition of the technologically literate person is the acquisition of quantitative skills including math modeling, probability, game theory, systems analysis, queuing theory, and other applied math processes. These are tools that are used in engineering practices, but are often given less priority by technology educators.

Not only are many technology educators in disagreement with NLA and STS, but technology educators themselves are not in agreement about the tools needed. Some expect students to be able to construct projects with the tools and processes of industry, others expect students to engage in designing products, while yet others believe problem solving is the best approach to teaching technological literacy.

If the technologically literate person is to be able to understand technology, appreciate its use, and use technology, the tools that are needed include the following:

1. An understanding of basic scientific concepts.
2. Quantitative skills, especially in probabilities, statistics, and systems analysis.
3. An understanding of societal needs and the values that underscore a society.

4. The ability to apply these competencies and knowledge to solving human and technological problems. This would include some psychomotor skills, but it is unrealistic to expect a person to develop proficiency in psychomotor skills as a result of one general education course. This problem-solving approach is often referred to as the technological method, which is different from the scientific method in both purpose and process.

FUTURE DIRECTIONS

Educational Needs of Citizens

Boyer (1987), when reflecting on the "educational and social purposes for the undergraduate experience," suggested that colleges serve two purposes:

> Individuals should become empowered to live productive, independent lives. . . . The individual preferences of each student must be served. But beyond diversity, the college has an obligation to give students a sense of passage toward a more coherent view of knowledge and a more integrated life. . . . Through an effective college education, students should become personally empowered and also committed to the common good. (pp. 68–69)

All people have a need to be in control of their lives and to have at least some influence over the people and events around them. Democracy and the free enterprise system rely on citizens who have confidence in their ability to make decisions about their own lives, as well as to influence decisions that are in the best interest of their communities. Hamilton (1993) notes that several elements are essential if people are to have control of their lives:

> First, they must have sufficient knowledge. Without knowledge, they cannot analyze the problems, perceive possible solutions, and/or make viable decisions. Second, they must realize that real choices exist. Knowledge without the possibility of genuine choice leads to little action and much frustration. Third, they must want to act. The desire to act derives, in part, from the belief that their choices will make a relevant and desirable impact. (p. 135)

If people do not believe they have any power, they do not become involved in the democratic process and often shortchange themselves in their career involvement as well. All education, not just undergraduate education, should be working toward empowering citizens. Educators must recognize, as Hamilton noted, that empowerment has as much to do with the affective domain (desire to act) as with the cognitive domain (knowledge), but to act without knowledge is to act irresponsibly. Considering the pervasive character of technology in society, technological literacy is essential to empowering the citizen.

Challenges to Technology Education

For most of this century, manual arts and industrial arts in the public schools were unchallenged by other disciplines. Although some tension existed internally between those who saw industrial arts as prevocational education and those who saw it strictly as general education, no other area of study was clamoring to teach about industry. Three significant events have occurred in the last 15 years that are causing changes: a shift of the knowledge base in our field from industry to technology, a renewed emphasis on interdisciplinary studies, and the growing acceptance of STS concepts in the public schools.

The first of these events—change of the knowledge base—was an internal decision over which the professional leadership had control. The other two events were the result of forces mostly outside the technology education profession. On the surface, a technology educator may feel that his/her domain is being challenged primarily from science, mathematics, and social science professional groups or from interdisciplinary groups drawn from these disciplines. Technology educators in many cases, however, are still fighting a shop teacher stereotype, often associated with industrial arts programs (and reinforced by administrators). Perhaps the best response to this stereotype is for technology educators to disassociate themselves from the industrial arts past and recognize that they are teaching content different from industrial arts with different goals. Some industrial arts educators and schools do not intend to change, and much energy can be wasted trying to change them. The focus for our energy should be on getting technology education into every student's education, not on worrying about the future of industrial arts programs.

Technology educators need to view the challenge of external groups—i.e., the other disciplines—not as a confrontation, but as an opportunity to become involved, to bring to the other disciplines a rich heritage of activity-based educational experience. Where STS or math/science/technology programs are being introduced in the public schools, administrators cannot justify two technology education programs. Hence, technology educators must become part of the planning and implementation teams or risk being eliminated from the curriculum. In some instances, a strong technology program has already sold itself to the administration and may have involved other departments in collaborative activities. This is a proactive approach that will help convince the administration, faculty, and parents that a viable and important program already exists.

Challenges from outside are important in helping the technology education profession focus on the purposes and knowledge base of technology education. This must be done, however, in the context of the other groups who now have an interest in including the study of technology in their disciplines. There is no assurance that technology education in 2015 will resemble technology education as it is today. It may be much better, it may also be taught within a different discipline.

Teacher Preparation Challenges

The interaction of the technological-political-economic-environmental-social-human value interface is difficult to teach at the middle school and high school levels, but is a particularly appropriate topic for the baccalaureate level student who has had some foundation in the liberal arts. In most technology teacher education programs, however, there is no attempt to help the student integrate sociology, psychology, political science, economics, science, mathematics, ethics, and environmental science. In addition, technology education students are not expected to take more of these liberal arts courses than are students in other educational fields. Reference was made earlier in the chapter for the need to require a number of liberal arts courses in the teacher preparation process. The study of the interdisciplinary nature of technology and technology decision making, however, requires new courses in most teacher preparation programs. The ideal course would be team taught or would feature presentations by representatives from appropriate liberal arts areas.

Program Implications for the Future

Throughout this chapter, recommendations have been made regarding the teaching of technology as liberal education. These recommendations are summarized in the following paragraphs. In the area of teacher preparation, (a) specify a general education core that will build a sound foundation for understanding the context in which technology occurs and technological decisions are made, and (b) develop one or more courses in the technology teacher education program that assist the student in "applying the mortar" that holds the foundation together. This means assisting the student in putting the knowledge from the different disciplines together into a coherent, understandable, interdisciplinary whole, which may require team teaching.

In the area of professional organizations, it is necessary to do the following:

1. Stimulate interdisciplinary thinking by inviting speakers and contributors to professional journals from other organizations and disciplines that have an interest in technological literacy, such as STS, National Science Foundation (NSF), and NASTA. Encourage members to request presentation assignments for conferences sponsored by these other organizations and cosponsor seminars and/or other events with these organizations. (Note: The International Technology Education Association currently has these goals in its strategic plan.)

2. Promote technology as liberal education within the discipline by supporting the development of sections or councils that focus on this field and solicit articles for professional journals on technology as liberal education. (Note: As this chapter is being written, a move to establish a section in ITEA for the study of technology at the college level is underway.)

3. Provide leadership and encouragement to define the outcomes of a technological literacy course for non-technologists at the baccalaureate level.

4. Encourage experimentation in technological literacy course design.

Members of the profession at the baccalaureate level need to (a) promote technology courses and technological literacy as part of the general education core at all educational levels, including the baccalaureate level; (b) become more involved in other organizations and conferences that have an interest in teaching about technology; (c) become more familiar with resources—journals, media materials, other literature—about technology that come from other organizations; and (d) explore the in-depth approach of studying technology and be open-minded toward different approaches to teaching technological literacy.

Unfortunately, the vast majority of colleges and universities across the United States do not have technology teacher education programs. To make matters worse, technology education programs are disappearing, swallowed up by industrial technology programs or simply eliminated due to low enrollments. Furthermore, many more courses focusing on technology are being taught by professors from other disciplines. If the technology education profession is to make any significant impact, it must become involved with other disciplines and other professional organizations that also have a commitment to technology education.

ACTIVITIES

The following is a list of suggested activities that the reader may wish to consider. They are not presented to represent the total universe of activities.

1. What skills and knowledge must a literate person have today? For one day, list the skills and knowledge you use that are required to function successfully in your society. How many of these were not necessary 25 years ago? How many of the skills and how much of the knowledge are technology related?
2. Review the list of characteristics of the scientifically and technologically literate person given by the National Science Teachers Association. Which of these are developed well by technology education? Which ones should technology education consider that are currently not being done well now? Which characteristics are not the responsibility of technology education? Do you think science teachers and technology teachers would provide the best education if they continued to teach their own curricula or if they found ways of combining classes? Defend your answer.
3. Review Figure 3–1. Is it a good model for technology educators? Why or why not? What should be emphasized more or less? Are the teacher preparation programs for technology teachers adequate or appropriate for teaching this model? How should teacher preparation be modified to teach this model or the model that you recommend? Create a new model that expresses your view of how technology should be taught, if different from the one given.

SOME RESOURCES FOR TEACHING TECHNOLOGY AS LIBERAL EDUCATION

The author assumes that the reader is familiar with the typical technology education resources such as *The Technology Teacher*, *Journal of Industrial Teacher Education*, *Tech Directions*, and the *Journal of Technological Studies* (A description of these journals are found in Chapter 19 of this yearbook.) The list that follows however, incomplete as it is, includes periodicals that have proven useful by this author for college level technology courses.

American Heritage of Invention and Technology: This magazine is published by American Heritage, a Division of Forbes Inc., 60 Fifth Avenue, New York, NY. General Motors is the sole sponsor. Fascinating, well written histories of technologies are based on the philosophy that "to understand the nature of progress and the roots of problems facing the nation, we need to appreciate the past."

Bulletin of Science, Technology and Society: Published for The National Association for Science, Technology and Society, University Park, PA, The STS Press. Each journal includes several articles about science or technology from an eclectic group of authors, in addition to educational materials, the table of contents of other current STS journals, and numerous book reviews.

The Futurist: "A journal of forecasts, trends, and ideas about the future. An association for the study of alternative futures. The Society acts as an impartial clearinghouse for a variety of different views and does not take positions on what will happen or should happen in the future." Published by the World Future Society, 7910 Woodmont Avenue, Suite 450, Bethesda, Maryland 20814.

Issues in Science and Technology: National Academy of Sciences, 2101 Constitution Avenue, Washington, DC. Scholarly articles on all aspects of technology development, use, and policies are included. "The journal is published to inform public opinion and to raise the level of private and public decision making."

Media & Values: Published by the Center for Media and Values, 1962 South Shenandoah Street, Los Angeles, CA 90034. This is a publication providing resources for critical awareness about media. The Center creates educational curriculum materials for local use, organizes forums and conferences, and maintains an information and resource center on the media issues of our time. 1 West 88th Street, New York, NY 10024.

NASTS NEWS: "The National Association for Science, Technology and Society was organized to address principles that identify Science/Technology/Society (STS) as process." The newsletter is a benefit of membership in the NASTS. Published by NASTS News, 133 Willard Building, University Park, PA 16802.

Perspectives in Biology and Medicine: Published by the University of Chicago Press, P.O. Box 37005, Chicago, IL 60637. "*Perspectives* is dedicated to insightful writing that analyzes the larger implications of today's newest scientific and medical discoveries. It synthesizes current scientific thought, placing biomedical issues within a broad, interdisciplinary context."

R&D: Research and Development: Published by the Cahners Publishing Company, a Division of Reed Publishing USA, 275 Washington St., Newton, MA 02158–1630. "Rather than dwelling on the past," states the editor, "we look ahead to where technology might be going." It contains excellent articles on cutting-edge applied science and technological developments.

SPEAKING OUT: *Realistic Approaches to Environmental Issues* (Volume 5). Published by Toyota Motor Corporation, International Public Affairs Division, 4–18 Koraku 1-chrome, Bunkyo-ku, Tokyo 112, Japan. "A series of articles that hopefully will spark further discussion, in this post-Rio age, on how to protect the global environment as well as provide ideas on how to meet the unprecedented challenge now facing the human race." The series is an excellent source of international articles.

Teachers Clearinghouse for Science and Society Education Newsletter: The Clearinghouse is sponsored by the Association of Teachers in Independent Schools, Inc., and is affiliated with the Triangle Coalition for Science and Technology Education. Its purpose is "to channel information on science and society education as well as data on available materials and other resources, and has established a collection of science and society educational materials for the benefit of all interested teachers at The Day School." 1 West 88th Street, New York, NY 10024.

Technology Edge: The Business of Innovation: This publication is published for college students and includes several articles on technology that have appeared elsewhere, trends of the future, interviews with graduates, job hunting advice, and book lists. Published by American Passage Media Corporation, 215 West Harrison Street, Seattle, WA 98119-8111.

Technology Review: Published by the Association of Alumni and Alumnae of the Massachusetts Institute of Technology, Cambridge, MA. The *Technology Review* is an excellent source of articles on technical subjects written in understandable language.

TIES: Technology, Innovation and Entrepreneurship for Students: Drexel University, 3219 Arch Street, Philadelphia, PA 19104. "A non-profit publication designed to help teachers increase students' technological literacy and capabilities; provide teachers with up-to-date resources for hands-on, design-based technology education curriculum; promote potential innovation and entrepreneurship; and is designed to reflect a comprehensive and evolving framework of technology."

World Watch: Publication of the Worldwatch Institute, 1776 Massachusetts Avenue, N.W., Washington DC. The magazine "monitors evolving environmental trends, attempts to make clear connections between the world's economic system and environmental systems, highlights effective efforts to reverse damaging trends, and points out problems yet to be addressed."

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CHAPTER 4

Technology and the Humanities

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One of the anomalies of human behavior is that little introspection or critique is made of the institutions of which the individual is a part. People go about their daily business rarely questioning whether any of their cultural institutions are serving the purposes for which they were created. At the same time, those very institutions are shaping peoples' behavior, for that is what institutions are supposed to do. An institution is far more than the common belief that it is bricks and mortar. The term *institution* as it is being used here refers to a complex of behaviors common to a large number of people in a given society. Those behaviors are handed down from one generation to the next as recognized solutions to recognized problems.

As a case in point, the concept of school developed when the family could no longer take care of the education that a child needed to function effectively in the society. Parents and church could only teach so much, and when that point was reached school was created, complete with specialists (teachers) who would teach students what the other institutions could not. Initially, the subjects taught by the school focused mainly on mastering the two major symbol systems of language (reading and writing) and numbers. In a simple, agrarian, frontier society not much else was necessary. Our society, however, did not remain simple. It became more complex so people needed to learn more and different things and the school was modified accordingly, at least in part. The problem of adjusting to change has always been a stumbling block for the school. It is caught in the whirlpool common to all cultures and made up of three components: change, conflict, and confusion. Those three C's have always dogged the footsteps of people who try to form educational practice.

On the affirmative side, American schools have done an acceptable job of enhancing literacy. This is borne out by the fact that over the last century and a half, literacy has been on the increase in the United States. In 1850, only 1 in 10 persons could read or write. Now we think it is tragic if everyone can't read and write. We may quarrel with how proficient they are in those skills, but the fact remains that the schools have done reasonably well in teaching the symbol systems of our culture. What can be said, however, about the schools' teaching of the nature of major institutions in American society?

Recognizing that institutions are more than buildings and that they are shapers of behavior, it would seem logical that part of the responsibility of the school is to acquaint young people with the essence of other institutions in their society. After all, the school is expected to help young people learn to live, work, play, worship, assume ownership of property, and be intelligent citizens. This stream of logic would suggest that the school should teach young people about the major institutions, at the very least. Has the school, as an organization done this? The answer would appear to be both yes and no.

Kinship, as an institution, is taught by comparing matrilineal and patrilineal societies, and by teaching property rights through primogeniture versus other cultural means. The institution of government or law is well taught in actual courses that deal with comparative governments, civics, politics, and many other subjects. The necessity to separate church and state in public education precludes an outright instruction of religion, but, religion is studied in a comparative sense. Hinduism, Shintoism, Buddhism, Christianity, Judaism, and Muslim are examined to discover similarities and dissimilarities. While this may be truer in higher education, it is often done in grades K–12 as well. These few examples are chosen simply to demonstrate that schools have taken seriously their responsibility to impart information about major institutions. This is the good news part of the equation, but is there any bad news? Yes.

Educational institutions do not deal forthrightly with a major institution—perhaps *the* major institution—of industrialized societies. That institution is technology. Technology is as fully and distinguishably an institution as kinship, law, or religion, yet it is rare that technology is recognized as a curriculum area and taught as an aspect of the general education of all students. Whether adult or child, technology touches every aspect of our lives. Technology is dominant in feeding us, paramount in our military defense, central in clothing us, an imperative in satisfying our housing needs, and entertains us through radio, television, and computer games. Even more pointedly, technology determines the nature of work performed, how industry is organized, the cycle of when we work and when we are at leisure, social class values, modes of entertainment, and even the distribution of population. How can it possibly be excluded from the curriculum if it plays such a dominant role in American society? The world is changing faster and faster due to technological innovations, yet we seem to do less to educate students about technology. This problem becomes more severe as time goes on since the knowledge base of technology doubles every five years. We, in America, are producing citizens who are, in varying degrees, technologically illiterate. Those citizens are not prepared to live freely, effectively, and with self-satisfaction and, of equal importance, they are ill prepared to contribute to the betterment of their society. This is a situation that every parent should find intolerable.

Primitive people had no need for formal schools. Life was simple, even if fraught with danger. The pressing concerns were to meet basic human needs such as food, shelter, physical safety, and human companionship. Of interest is that these primitive people made drawings on the walls of caves depicting how their essential needs were met. Those drawings should not be overlooked in terms of their importance to technology and its relationship to the humanities. Before those symbols (drawings) could be executed there had to be some idea, thought, or conception about what was to be placed on the walls. After the thought came the execution (technology) of the drawing. The production of the drawing has been described here as a two-step process, when, in fact, thought and action were parts of the same process. People had to think and develop symbols long before tools were employed. Mumford (1970, p. 1) takes this position in describing his earlier books by saying " . . . they were . . . audacious in denying that man's departure from animalhood and his continued development rested solely on his propensity for tool-using and tool-making." The fact is that man was forced by the exigencies of living to think about how to better the conditions of living. That thinking process was technological innovation, the very genesis of technology.

RELATIONSHIP BETWEEN TECHNOLOGY AND TOOLS

Technology educators have a tendency to romanticize technology and the use of tools by early humankind, but the fact is that until the 16th century, technology and tool use had developed rather slowly. As previously stated, it was only after symbolic functions had reached a high level that technology, tool use, and toolmaking emerged as dominant factors in human development. Early cave paintings demonstrate that, although technology is involved in painting, the symbolic arts were far in advance of tool development. This should not be surprising, for technology would be impossible without symbols, symbolization, and problem solving.

To those who are naive about technology, the term itself implies tools, or it suggests three-dimensional objects such as lawn mowers, floppy discs, space probes, lasers, and VCR's. While this association of tools and machines with technology is in part accurate, it is equally accurate that the classification of objects as tools is entirely arbitrary. To explore this arbitrary association, the author (Waetjen, 1988) asked college students to identify which of four objects presented to them were tools. The objects were an abacus, geometer's compass, multiplication table, and a table of logarithms. They were quick to name the abacus and compass as tools, but only rarely did they opt for the other choices. Objects identified as tools had in common that they were three dimensional in nature and were related to physical action. One cannot quarrel too vigorously with these characteristics, for action is inherent not only in a tool but in technology as a process. This thought is captured by Lawrence (1985) who states, "Technology must be seen as *disembodied knowledge and technical art*, not just as hardware" (p. 34). While Lawrence gives no clear description about the meaning of the term disembodied knowledge, it is convenient to see it as symbols. As important as symbols are in the technological process, one must be careful not to infer that tools are correspondingly unimportant. Tools are a part of technology, yet they are not the sole part.

Cassirer (1944), who seems to use the term tool as a synonym for technology, reminds us that technology and the satisfaction of human needs is not tied to the moment. He states that

> . . . in order to invent a tool, as such, it is necessary that man lift his gaze above the sphere of immediate needs. While fashioning them he is not acting from the impulse and necessity of the moment. Instead of being moved immediately by an actual stimulus, he prepares the means in advance. The purpose which the tool serves involves within itself a definite pre-vision. The impulse does not derive solely from the force of the present; instead, it belongs also to the future, which must be anticipated in some fashion in order to become effective in this way. This 'pre-presentation' of the future characterizes all human action. (p. 75)

The pre-vision of which Cassirer speaks is the symbolization so integral to the technological process. Only through symbols can one plan or provide for future actions.

Much will be said in this discourse about the important role that symbols play in every aspect of human functioning. Symbols can be significantly more complex than those on a mere road sign. They are entities that "package" information. A symbol is a way of referring to any other entity that may or may not be present. Those things may be material or abstract and include such categories as words, numbers, pictures, diagrams, maps and other communication devices used to interpret and to represent some kind of information. Only a moment's reflection makes it clear that an individual may have symbols that are unique to him/her alone, but symbols are the most useful when they are part of a shared symbols system. A shared symbol system is one that has common meanings and communicates much the same information to a group of people. In this connection Gardner (1983) states the following:

> Symbols can function alone as meaningful entities; but very commonly, they enter as components or elements in a more highly elaborated system. Thus, words figure in spoken or written language; numbers and other abstract symbols in mathematical languages; gestures and other movement patterns within dance systems; and the like.

Both symbols and symbol systems achieve their greatest utility and value in their symbolic products such as rituals, stories, dramatic productions, poetry, and solutions to problems. There is a temptation to add technological products to this list, but that would assume a shared symbol system for technology. Does technology have such a shared system of symbols? That question will have to be answered by the profession in the near future if it is to be recognized as an academic discipline.

DEFINING THE HUMANITIES

Most people believe that thought and action are two separate behaviors. (Even worse, there is a common belief that thought is superior to action.) It is easy, therefore, to translate that same type of notion into the humanities and technology, that is, the humanities are thinking while technology is doing (action). The dichotomy in how we view these two human activities is endemic in most industrialized societies. Sadly, even educators hold this view, yet, for many years philosophers have firmly maintained that thought and action are unitary. Before examining their considered views on the subject, we must be quite clear about the nature of the humanities.

What are the humanities? Can they be defined with any precision? They probably cannot, but they may be defined in a manner that gives a reasonable understanding of their nature. Crane (1967) makes an excellent statement that helps us to comprehend the general nature of the humanities.

> When the Romans first spoke of *humanitas* they used the word to mark off those activities of man by which he is most completely distinguished from the animals, and they identified these with the activities by

which man brings to perfection the twin faculties of speech and reason. (p. 166)

Crane (1967, p. 161) contends that humanity consists of the powers or possibilities that people realize when they develop languages, produce works of literature and art, or build philosophical, scientific or historical constructions. A like view, and one of particular interest to technology educators, is that of the philosopher Cassirer (1944) who feels that man's outstanding characteristic is not his metaphysical nature, but his work. He says, "It is this work, it is the system of human activities, which defines and determines the circle of humanity. Language, math, religion, art, history, science are the constituents, the various sectors of this circle" (p. 166). The *Report of the Commission on the Humanities* (1980) conceived of the humanities as having languages and literature, history and philosophy as their core. More minor fields include religion, law, archeology, and ethics (p. 3). Interestingly, these same disciplines define a sharp difference between humans and the animal kingdom.

THE RELATIONSHIP OF THOUGHT TO ACTION

Setting aside specific disciplines, the humanities are most distinguishable by language, reasoning powers, and the works produced by humans utilizing one or both of these abilities. To accept such a position would recognize that in any technological act there would have to be reasoning (thinking) and some type of work. In other words, thought and action could not be separated. Bergson (1911, p. 169), while commenting on the evolution of man in the context of technology, states that the intellect can only be judged in relation to action and its primary aim is to produce artifacts. One may infer that these artifacts do not relate only to three dimensional objects. What emerges is that the intimate interaction between thought and action is the key to understanding the relationship between the humanities and technology. Arendt (1958) makes this point explicitly when she says, "The thought process by itself no more produces and fabricates tangible things, such as books, paintings, sculptures and compositions, than usage by itself produces and fabricates houses and furniture" (p. 169). She contends there is a reification that occurs when a person writes something, composes a song, or constructs something, and that the reification is directly related to the thought that gave rise to it. She goes on to say that ". . . what makes the thought a reality and fabricates things of thought is the same workmanship which through the primordial instrument of human hands, builds the other durable things of the human artifice" (p. 169). Even Jacques Ellul (1965), who is one of the most vocal critics of technology and has termed it "technique," believes that the distinction commonly drawn between thought and action is destructive to the furtherance of society. It is his opinion, moreover, that thought and activity are a unitary behavior. He comments that industrialized societies have erred in permitting a distinction to be made between thought and action because of our preoccupation with objects, artifacts, and machines.

The description of man as a tool-making animal has become so firmly embedded in the minds of people as to make it almost impossible to shake the idea, or, at least, to examine its validity. More than a century ago Thomas Carlyle portrayed humans as tool-using beings, with the assumption that this single trait elevates them above all other creatures. Mumford (1966) states, "This over-weighting of tools, weapons, physical apparatus, and machines has obscured the actual path of human development" (p. 5). The fact is that there was nothing particularly and uniquely human in tool-making until it was altered by language symbols. It was the human brain, not just the hand, that made the great difference at that point. One theory of human development holds that first the brain expanded to a significant degree because of some change in the structure of the genes and subsequently humans had the capacity to make tools. The facts suggest, however, that there was a back and forth process between man's cortical capacity and his tool-making. Weltfish (1968) makes the following point:

> . . . it is clear that as the skill of man's hands increased, his brain expanded accordingly, the two factors moving along in close interrelationship in the subsequent course of history, pointing to the fact that the progress of thought and action were never very far apart. (p. 234)

This same thought is expressed by Mumford (1952), albeit in a somewhat different way, ". . . man is both a symbol maker and a toolmaker from the very outset, because he has a need both to express his inner life and to control his outer life" (p. 161). Nevertheless, Mumford (1970) seems to place emphasis on the role of symbols when he says the following:

> . . . the idea of time is more important than any physical instrument invented for recording time; and this idea took form in the human mind, with no other instrument than the naked human eye observing planetary motions and calculating them with the aid of mathematical symbols that likewise existed only in the human mind. (p. 419)

The evidence seems overwhelming that thought and action cannot, were not, and will not be divorced in the practice of technology, no matter the prejudice or ignorance of the populace in general. Perhaps Coombs (1985) sums it up the best when he says, "It is important to bear in mind that technology does not simply design tools – or create hardware – it brings an idea and a tool into creative association" (p. 3).

Technology's usual manifestation is some type of action in order to produce a tool or object, to effect a new process, or to develop some other kind of aid. Because of that manifest action, it is easy to comprehend why many people believe thought is unrelated to technological behavior. It is the action aspect of technological behavior that is observable, so it is understandable that uninformed people would overlook the thinking aspect of technology. Surely scholars have not ignored or overlooked the creative association between thought and action, but the general public views technology as action alone, as almost a mindless activity, and this has had negative consequences on technology education. Technology, along with some other activities, has been relegated to a lesser place in the hierarchy of courses or subjects offered in the school curriculum. Why should this be and, more importantly, how did this come about? Whatever the answers, it is clear that the humanities as well as technology have suffered from this split in attitude. The humanities, to most students, would be identified as almost exclusively concerned with mental activity and technology concerned almost exclusively with action. Even a casual glance at a college curriculum will demonstrate that students do not have exposure to technology as an integral part of their general education.

HISTORICAL BACKGROUND

There were at least four major historical incidents that either caused or contributed to the acceptance of distinct divisions between thought and action. None of these incidents derived from arcane motivations or efforts to undermine either technology or the humanities. At the time of the early Greek civilization there was no distinction drawn between thought and action. In that civilization the academy provided a rigorous and comprehensive education to a group of students who were destined to become leaders in the society. Only 10% of the population was educated in the academy, however, while all the rest who did not even enjoy citizenship, performed more manual types of work. In short, it was the organization of the Greek society that created the split between thought and action. Using the term liberal education in a generalized sense, Foerster (1946) describes the Greek society by stating that "When liberal education arose in ancient Greece, it was the discipline of free men – the unfree learned the vocation" (p. 42). The longer term effect of this split between how different groups of people were taught was a society having two levels. One level was uneducated, did menial labor and performed artisan activities. The other level was educated in the academy and did not perform any type of manual work. It is not surprising that those in the first level were regarded by the others as inferior since they were often required to do work that was dirty, even if highly skilled. They became the victims of an attitude that work was a lowly form of human activity and, if possible, was to be avoided. Thus was born a dualism between things of the mind and things of the body. Equally pernicious, as far as technology education is concerned, is that this dualism has persisted to the present day. No matter how vehemently we may deny it, aversion to work still extends to those who perform it. Precious few parents want their sons to become highly skilled tool and die makers if they have the opportunity to be a lawyer, no matter how competitive and underpaid the latter profession may be. The legacy we have received from the ancient Greeks is puzzling. On the one hand, their philosophers embraced fully that thought and action were a part of the same parcel of human behavior. On the other hand, the social roles assigned to certain activities most certainly made a sharp distinction between thinking and action. Whether or not this was the first instance of that sharp division is difficult to tell, but surely it was a milestone.

The lifetime of Charles II (1630–1685) was a period of considerable intellectual ferment, as well as frustration, for scientists of the time. As early as 1645 these scientists found that their thinking and experimentation were severely constrained on university campuses because of influences of the church or the government. In 1645 these scientists formed what they called The Invisible College, an entity entirely separate from the universities. When Charles II came to the throne in 1660, he took a strong personal interest in The Invisible College. He granted it a charter as the Royal Society of London For The Promotion of Natural Knowledge on July 15, 1662. Early members of the Royal Society included mathematician John Wallis, microscopist Robert Hooke, astronomer Edmond Halley, and architect Christopher Wren, all of who subscribed to the work of Francis Bacon. Mumford (1970) states that a notable achievement of Charles II was to charter the Royal Society in 1660, the aim of which was "to improve the knowledge of natural things, and all useful Arts, Manufactures, and Mechanick practices, Engynes, and inventions by experiments" (p. 115). Within 15 years of its chartering, the Society had organized itself into eight committees, which gave focus to the work of the Society. The eight committees were Mechanical, Chemical, Surgical, History of Trades, Astronomical and Optical, Anatomical, Phenomena of Nature, and Correspondence. The strong scientific bent of these committees is quite apparent, but comes as no surprise. A member of the Royal Society, Robert Hooke, early on had written a document that had the effect of staking out the purview of the Society. In pertinent part it averred that the Society would give no consideration to such things as, "Divinity, Metaphysics, Morals, Politicks, Grammar, Rhetoric, or Logick" (Mumford, 1970, p. 115). Every one of those prohibited areas of consideration, with the exception of Politicks, could logically be called an aspect of the humanities. One might easily assume that there was a cabal against the humanities, but this was not necessarily the case. Excluding those specific areas of consideration protected the Royal Society from interference by the Church or State, that is, the Royal Society only pursued knowledge in fields where it would have freedom to do so. This decision had good and bad consequences, like most acts of human endeavor. The good consequence was that the general pursuit of science was furthered tremendously, with a strong Baconian stamp on that work. A highly utilitarian and practical use of science emerged through the development and use of the scientific method. The bad consequence was that there was deliberate avoidance of interplay with those subjects that today would be called the humanities. This omission had far-reaching consequences that have extended to the present day. If there had been interplay with the humanities, there might have been additional consideration given to our mastery of the natural world and to the environmental consequences of human actions. Only in more recent years has technology examined the environmental impact of certain technological innovations. Had we done so earlier, there is some likelihood that we would not have dioxin in streams, acid rain destroying forests, and holes appearing in the ozone layer.

In the larger picture of human development, the avoidance by the Royal Society of consideration of the humanities put an irrevocable stamp on activities such as chemistry, surgery, astronomy, and mechanics as having no kinship to religion, philosophy, or grammar. The result was to define truth in terms that were almost exclusively scientific or technological. Thus were removed from consideration such things as human values, man's purpose in being, and even practical applications of knowledge that had already been discovered. This distorted notion of truth or reality has had an enduring and pervasive quality. Even today the distortion persists, although in a modified form. It should be understood that neither Charles II, the Royal Society, nor Robert Hooke intended that such a division would be accepted as ideal, or that it would persist over the centuries. They were simply responding to political realities of their times.

The third major historical incident that gave rise to the division of thought and action was the Industrial Revolution. Begun in England in the 18th Century, the Industrial Revolution later flourished in the United States, and for very good reasons. Retrospectively, it is clear that the spread of the Industrial Revolution to this country was made possible by a combination of unique conditions. These conditions created a technological pool that was probably unprecedented in human history. The pool had four aspects to it. First, there was a burgeoning of accumulated scientific knowledge which had been acquired as a result of the establishment of the Royal Society two centuries earlier. That knowledge seems to have reached a certain critical mass about the middle of the 19th Century. Second, the United States had an abundance of natural resources which were becoming more available with the opening of the West and the maturation of the extractive industries. Those natural resources were vital to creating all manner of products to satisfy human needs and to create new tools and machines. Third, there was a cadre of skilled artisans who were the products of an apprenticeship system that had evolved from the guilds of earlier times. Fourth, there was not only a premium placed on inventing, but there seems to have been a special talent for it, perhaps because of the huge potential for rewards if an invention were successful, coupled with the strong work ethic practiced at that time. These four aspects of the technological pool defined an era, the chief hallmark of which was action. For the general public it was doing things, making things, and constructing objects that were highly visible. So great was the emphasis on these actions that the thinking, planning, and problem-solving inherent in them was overshadowed. The effect was to perpetuate the legacy from the ancient Greeks and the Royal Society.

The fourth historical incident worthy of mention in the context of the separation of thought and action is of rather recent vintage and is closely associated with the automobile manufacturing industry. The incident was the rise of standardization and interchangeability of parts. It is told that assembly line production depended upon all parts being interchangeable, much like a slaughter house in reverse according to Henry Ford. He observed a slaughter house where each worker removed one part from the total animal carcass and thought that the process, in reverse, would serve the automobile industry remarkably well, *if* the constituent parts were interchangeable. The industry did, in fact, thrive from this change in an economic sense, but it aided in separating thought and action. It removed the workers even further from the thought processes required to create a finished piece of work, whether a complete engine, a complete front end suspension, or a complete transmission. Their activities were now directed exclusively toward one piece of the total object being built. The thought necessary to see an entire project was no longer needed. In many ways, even the preset, automatic type of machines (such as turret lathes and screw machines) caused thinking to be relegated to an even more minor part of the mechanic's role. Interestingly, these automatic types of machines did as much to determine the operators' behavior as operators did to determine the behavior of the machines. As a result, the worker had been removed from a large measure of the process of creating an object and had been reduced to a cunning hand.

Thought and action have been on divergent courses for many centuries. The separation came about not because of some grand plot, but by a series of presumably well-intentioned decisions. Regardless of causes, the fact of the matter is that the humanities became separated, for the most part, from technology. Stated in another form, symbols became divorced from the actions associated with tools, materials, machines, and the processes of technology. The divorce of symbols and tools (technology) seems a paradox, for both serve the similar purpose of creating order. It was orderly that a given symbol had common meanings attached to it within a given social group. Arnheim (1971) stated, "Order is a necessary condition for anything the human mind is to understand" (p. 1). It was orderly that a given tool or process be used to satisfy certain human needs. The propensity to introduce order into all human activities runs deep in people. Some would believe that it is the way in which humans strive to reverse or to impede the tendency of all things in the universe to move toward disorder or degradation. Ordering gives humans a sense of predictability and stability, thereby making the world a more comfortable and safe place in which to live.

CHAOS THEORY AND TECHNOLOGY

If there is anything unpredictable or chaotic in the technological process, it is the anticipation of human needs. If there were a logical, predictable stream of unfolding human needs, technological innovators would find their task significantly easier—and more lucrative. The fact is that there is chaos in some degree in many things, not just technology. Science traditionally has been concerned with order, regularity, and a precise chain of cause and effect, a legacy from the work of the Royal Society. English mathematician Sir Isaac Newton developed his laws of motion and gravity with the idea that all things in the universe are measurable and are as predictable as clockwork, provided there was enough information about them. Scientists long believed there are only two types of motion: steady state and periodic. An example of steady state is the car in the garage that hasn't moved since being placed there, while periodic is exemplified by the orbits of the planets. Early in this century, however, the French mathematician Poincaire hypothesized that a third state of motion exists and that it is at once turbulent and unpredictable. He found that disorder emerged in large complex problems having several parameters. (This may be likened to a problem in technology where the parameters may involve math, science, social conditions, and economic factors.) As early as 1903 Poincaire stated that prediction is impossible because small differences in initial conditions can produce huge differences in the final condition. That statement actually defines the science of chaos, which is that small changes in initial conditions will result in major changes in the longer term. Fenton (1992) helps in understanding the theory of chaos when he states the following:

> The term 'chaos' is used by scientists not in its conventional sense of total bedlam, but rather in a specialized way. Chaos theory deals essentially with the concept of order within disorder. Turbulent, seemingly chaotic systems—governing, for example, the swirl of a fluid or the waft of a smoke ring—may look as if they behave randomly. But . . . . they exhibit an underlying long-term order that is neither wholly deterministic nor wholly random. (p. 1)

What is of concern to technology educators is that the theory of chaos may have significant relevance to technology. Surely it cannot be disregarded, for chaos theory is being recognized by many as one of the major discoveries of the 20th Century, along with Einstein's theory of relativity and quantum mechanics. Technological innovation is an exceedingly complex system where there is, presumably, disorder even within the order of the technological process. Discovering that order with disorder involves cognition and application, knowledge and control, mind and matter, purpose and tools, will be of increasing importance to those in technology education.

TECHNOLOGY AS A HUMANITY

Due to the separation of thought and action, the humanities and technology have become almost inimical to each other in the minds of the common people. The long-term effect of that separation is incalculable in terms of attitudes about work, choice of occupation, and content of both the high school and college curriculum, to mention just a few. Yet, if the humanities are the most distinguishing features between humans and animals, technology would surely have to be included among the humanities. Nit pickers would claim that the otter's ability to crack clam shells using rocks is technology and that nest building by birds is also technology. Those abilities, however, are instinctive, built into the nervous system of animals or birds, and are not technology in the sense being used in this discourse. Animals are not capable of recording history, of philosophizing about the nature of their very being, of using mathematics to solve complex problems, or of engaging in religious behavior. Lower animals are not capable of developing and utilizing the symbols so vital to the process of technological innovation. It is quite clear that the hallmarks of humanism are the powers of language, the ability to reason, and the works that humans produce by making use of one or both of the foregoing.

The term *implication* carries with it a connotation of a close connection between two things. In this case, what are the close connections between technology and the humanities? This entire discourse has attempted to make the point that the connections are closer than is customarily thought. If that be the case, there must be some areas of action an educator could take in order to make clear that the humanities and technology are not inimical to each other. Those will be explored here.

Educational Implications

For the entirety of the educational enterprise, an accepted implication is that all of the humanities (including technology) be viewed and taught as being skills of inquiry and reflection. Some would argue that technology is more than inquiry and different than reflection, but that is not the case if technology is treated as problem solving. The inquiry becomes problem solving. Reflection becomes an aspect of the solving of problems, especially when it is necessary to devise alternative solution possibilities if the first solution proves to be unsuccessful. When the humanities are taught as skills of inquiry and reflection, students are able to process information about large fields of study and not to see the humanities merely as subjects. In short, emphasis should be placed on the mental processes in the humanities and technology. Taught in this way, the humanities would provide students with self-educative learning devices that would enable them to keep up-to-date with the emergence of new information in the future.

In most disciplines knowledge is created in a unique manner, but in American education we don't teach students in the same way that knowledge is created in that discipline. In history, for example, the discipline is taught not as the literature of evidence but as a body of names and dates, most of which are associated with military events. It could be presented to students in the same way historians approach their work, that is, they identify an important event, collect as many facts as are relevant to it, and then make sense of the welter of facts. This process calls for analysis and critical thinking; more importantly, it is historiography, which is the knowledge and understanding of historical situations and causes. Typically, history is not taught in that way. The end results, findings, or analyses are symbolized for the student in the form of written words in a textbook, and then the task of the student is to memorize the facts represented by those symbols. It is small wonder that students find this form of teaching, as well as their role in learning, to be unchallenging to them. Not only history, but almost every discipline is taught in the same manner. Technology, as a case in point, is sometimes taught by reading about great inventions such as paper, the steam engine, telephone, and microchip. Again, symbols are used to impart the information. Unfortunately, the symbols are not those the learner created. This situation has been modified by recent changes in the mode of technology education to include the opportunity for students to use tools, materials, and machines to solve technological problems. Knowledge is not symbolized first and then given to students who are expected to internalize it. The students create the symbols by going through the same process technologists use to create knowledge. This is something we need to learn to do in all aspects and phases of education.

If education has a shortcoming, it is that symbols are taken for granted. How strange that this should be so, since the most important thing about human beings is their ability to symbolize. Why should we not teach students what symbols are, how they are developed, the very valuable role they play in learning, communicating, and in problem solving? At present, the significant act of symbolization is treated as though it does not exist, and in so doing students do not come to appreciate the full extent of what it means to be human, or to realize what tremendous power every individual has simply because of this unique capability. By not focusing on symbols, we deny students the opportunity to make the connection between a symbol and the thing for which it stands. The word *barn* is different from the three dimensional object barn; a map is different from the physical territory it represents; the gestures in a Hula or Kabuki dance stand for many things other than the immediate gestures. It is understanding the connection between symbol and referent(s) that is now overlooked, ignored, or disregarded. Why this does not happen is clear: the teacher preparation institutions do not include it in their instruction, although teaching about symbols and symbolization could be done at every developmental level, in appropriate ways.

Hardly any student goes through school without having had some exposure to the Industrial Revolution. Usually, that exposure has dwelt on the great number of inventions that came about and how those inventions made life easier. Rarely is consideration given to the reasons why those inventions emerged. Yet, the talent for inventing was only one of several factors that made the Industrial Revolution a watershed period in human development, as well as in American society. The technological pool that made the Industrial Revolution possible, along with its inventions, is a testimony to the thinking powers of people of that era, but we give them short shrift. There is every reason to examine all the dimensions of the technological pool and, along with it, to acquaint students with the key role that technological heritage plays in modern economy. We do ourselves a disservice by underestimating the powerful influence that technology has had in industrialized societies. It is common knowledge that technology produces gadgets, but not commonly known that it expands human opportunities, improves human productivity, provides greater efficiency in the use of the earth's resources, affects military strength, and impacts international trade. Goldsmith (1970) states, "Every . . . study has shown that more than half of the overall growth in national or international product . . . can be attributed to technological innovation" (p. 3). Education needs to communicate to students the importance of technology to the well-being of our society.

Even a casual observation of the structure of education at the elementary school, secondary school, and college levels reveals a system in which students are exposed to a variety of subject matter. Reading, social studies, history, physics, chemistry, biology, and algebra are presented to students as separate entities. For example, a high school student on a given morning may have history, then chemistry, and English, with afternoon schedule made up of additional subjects. The most difficult task is not that of learning the concepts in each of the subject areas, but of seeing how the subjects are connected. Curiously, we leave that job to the students and do little or nothing to help them put their knowledge together so that it makes sense. Why do we abandon students when they most need help? Maybe it is because we have not come up with creative techniques for helping to integrate all the information that is taught separately to students. The implication is that educators, at all levels, could devise means—courses, seminars, independent study for integrating knowledge. If these means were devised and proved to be effective, it is entirely possible that students would see more relevance in their education, that achievement levels would rise, and that dropouts and truancies would decrease.

The body of this chapter has developed the point that technology and the humanities are natural allies, even if they have not been treated as such in the past. That implication needs to be made explicit. There is every reason to develop a strong alliance between the humanities and technology. The separatism that has been imposed on these two large areas of knowledge does not make educational sense in a world and a time when knowledge is not only expanding at an exponential rate but is fragmenting. Indeed, the humanities appear to offer technology opportunities that have not heretofore been realized. After all, humanists and technologists are all in the process of furthering humanity and producing cultured people. Cassirer (1944) alludes to this clearly in the following statement:

> Human culture taken as a whole may be described as the process of man's progressive self-liberation. Development of language, art, reli-

> gion, science are the various aspects of this process. In all of them man discovers and proves a new power—the power to build up a world of his own, an 'ideal' world. (p. 237)

While the quotation makes no direct reference to technology, it is implied in the phrase indicating that man has the ability to create his own world. Before this alliance with the humanities can occur, it will be necessary for those in technology education to become fully conversant with the humanities. Only then will they be able to see relationships and connections and be able to further them. The same thing must be done by those who teach the humanities. They must come to know and understand technology and how it is taught. We in technology education have an obligation to show humanists how, to use Cassirer's term, we can help people to build a world of their own. Humanists have the same responsibility. Who will dare to take the first step?

Incorporating Technology Into The Educational System

Secondary education in the United States has come under heavy fire, particularly during the last decade. Negative comparisons are made to students' achievement in other countries and comparisons to test scores of the past are given as examples of the declining quality of the secondary school. While some of that may be true, this discourse seeks only to suggest ways the secondary schools might improve by forging alliances between the humanities and technology education.

Earlier it was stated that technology is a major institution in the American society, perhaps even *the* major institution. Teenage students are fully capable of understanding the concept of institution as this chapter defines it. They need to know that institutions of any society tell a great deal about how a society is organized and what its values are, as well as how those institutions shape the behavior of millions of people. That type of instruction could occur in history classes, art classes, social studies and civics classes (humanities subjects) and by all means, it could occur in technology education laboratories. Were this to be done, it is conceivable that the role of technology in the American society would be understood better. It could help students to realize that technology is not just another institution, but is what makes possible the standard of living enjoyed in America. It could help students to appreciate that much of foreign trade is related directly to technology. All of this can be done without demanding that students develop tool skills, while giving them the opportunity to use tools and materials to solve the kinds of problems that technologists face. To do all of this requires that curriculum makers and assistant superintendents in charge of instruction be apprised of the concept of institution, perhaps by technology educators.

In recent years, technology educators have formed working alliances with math and science professionals. That is an entirely wholesome development since the three disciplines are intimately related. Those alliances should be encouraged to continue. Now we need to look for new alliances, very closely related and with a mutual affinity. One of those is the synergism between technology education and language. That relationship might surprise a great many people, but it should not. Given the fact that technology education is carried out by virtue of problem solving, the relationship comes into clearer focus because problem solving, if carried out properly, absolutely requires the use of language. Waetjen (1989) states the following:

> Language is a means of thinking as well as communicating. Since problem solving, learning, and thinking are one and the same thing, it would follow that language in both its oral and written forms is the major tool of problem solving. Language is the most important symbolic tool available as an instrument of thought. (p. 7)

What is important to recognize here is that both the language arts and technology education are heavily dependent upon symbols, whether they be written or oral. What is needed is for instruction to bring about more discussion that acknowledges how symbols play a part in technology and in language. A very specific way in which teachers might cooperate has to do with fostering student metacognition. Presseisen (1986) states, "Metacognition involves students in becoming conscious of their own ways of thinking, of exploring various possible routes to resolving a particular problem, of intellectually becoming engaged with the learning experience driven by self-motivation, curiosity, and . . . by necessity" (p. 12). Bearing in mind that thinking involves both the use of and development of symbols, metacognition becomes an extremely important tool for teachers in the language arts and technology education areas of the curriculum. Metacognition causes students to pause and reflect on their previous thinking and problem solving to determine whether it was effective, what parts of it were or were not useful, how they might modify their thinking, and how they might be more autonomous in learning. What it does is to place students in control of their learning. That is what teachers have striven for since the beginning of formal education and have achieved only seldom. Speaking of the matter of control, Osburn, Jones, and Stein (1985) state that ". . . metacognition refers to individuals' knowledge of, and control over, their own thinking and learning. It involves not only knowing what one does and does not know, but also knowing what to do when one fails to comprehend" (p. 11).

It would seem that if technology education is designed for all students and is an aspect of their general education, then secondary schools might do another thing to enhance learning by making clear distinctions among the terms *technology*, *tools*, and *machines*. In particular, students need to learn that technology and tools are not one and the same thing. Tools may be an aspect of technology and they may be used in solving technological problems, but the mere existence of a tool does not constitute technology. This is especially true of tools that have a three dimensional character and are used for shaping materials. There are other tools. Should we not have students learn that a table of logarithms is a tool, that a formula is a tool? Those ideas may offend some who think of a tool in a mechanical rather than a problem-solving sense. Sometimes the very nature of our language confuses the distinction between tool and machine. When students are told that a screwdriver is a tool and an engine lathe is a machine tool, it is understandable that they would see each of those in a similar manner, even if one is more complex that the other. A tool, usually hand held, by its very nature places the user in the position of being more of a creator, having greater flexibility in use of the tool, and adapting its function to an infinite number of situations. In contrast, a machine is designed for a more limited number of functions and, in many ways, dictates what the operator does. A tool places the user in a position to determine how it shall be used to a greater extent than a machine, which acts upon the operator's behavior. If those are subtle differences, they are helpful in understanding how human behavior is shaped differently by tools and machines.

More than any other institution in the entire educational system, higher education is guilty of neglecting to expose students to the importance of technology. Of course, it is sometimes taught in economic courses as an aspect of the total economic structure and it may be touched upon in a history course when considering the Industrial Revolution. As useful as that exposure may be, the fact is that it is only studying *about* technology. What students need is to study *in* technology. The difference is that in the latter students are addressing themselves to solving problems of a technological nature using tools and materials to do so. This is vastly different from reading symbols in a book about the Industrial Revolution. It is no less than imperative that students learn how knowledge is created in various disciplines whether those disciplines be history, religion, art, philosophy, or technology. At the present time, we simply do not do this in the curricula of higher education. Whether the general requirements for graduation take the form of a distribution formula or a core of courses, college students are not exposed to technology. How, then, can we really say they are educated upon graduation if they have not had firsthand experience with a major institution of the American society? We can't, unless we blind ourselves to the obvious.

NEED FOR RESEARCH IN TECHNOLOGY EDUCATION

If the Industrial Revolution was a watershed event in the stream of human development and the evolution of the United States, it is interesting to speculate whether there could be another revolution. The Industrial Revolution touched off the manufacturing activity and age. Is it at all possible that in the information age another technological pool could be created? Technology educators at the higher education level might well address themselves to this question along with graduate students. Are there modern counterparts to natural resources, to an accumulation of inventions, to a cadre of highly skilled technicians, and a large body of accumulated scientific knowledge? Should one or more of those components be missing, graduate students might debate how they could be made available and what the humanities might do to abet the creation of these component parts. The emphasis here must be made clear. The call is for technology education to be a creator of knowledge and not simply a consumer. The point deserves elaboration.

Typically, people in technology education do not conduct research. If they do, it is usually to satisfy a degree requirement and is of a survey nature. The people in the profession would do themselves a great service by collectively declaring a moratorium on surveys so that they could do the type of research that adds to the knowledge base of technology education. Therein lies a significant problem since the knowledge base of technology education is practically nonexistent. Because there is such a paucity of research findings, we have great difficulty justifying the inclusion of technology education in a mandated curriculum. We resort to anecdotal evidence or professions of high hopes and deep aspirations as to what technology education does with and for students. That is not enough. There are exciting things that can be done by forming working research alliances with people from the humanities. The research topics are manifold and chances are that the findings would benefit both technology education and the humanities. The likelihood is that secondary school students would be needed as subjects and, if so, the secondary school teachers should be brought into the research planning as equal partners. One example of research that might be done integrating the humanities with technology education has to do with metacognition. Every one of the humanities, whether art, history, philosophy, literature, math or religion, would benefit, as would technology education, from knowing how students use metacognitive skills after a given unit of learning. Of even greater utility to teachers would be research on the way in which metacognition could be enhanced in each of the disciplines mentioned previously.

The need to build a knowledge base for technology education is so great as to make it impossible to describe it in words. Should we not build this knowledge base created mainly from research findings, we will become, to use Bertram Russell's words, an "enterprise of methodical guessing." A pivotal aspect of the knowledge base would be the determination of the symbols that are unique to technology. Higher education is in a unique position to investigate what the symbols are and if they are arranged in a system. Whatever the case, attention should be given to how or if these symbols are shared with the various disciplines of the humanities. What would add credibility to research of this nature would be to conduct it with people from the humanities. This cooperative effort would add a unique perspective to the definition of the research problem and also to the methods used for data collection. Teaming up with humanities professors would help them to develop an appreciation for technology education and those who profess it. The importance of that side effect should not be underestimated.

The emerging discipline of chaos poses interesting opportunities for technology education. The discipline is in its formative stages as those involved in it would attest. While chaos had its origins in mathematics, recent thinking has extended it to movement in the economy, to the social sciences, and to the study of population dynamics. Even more recently, chaos theory has been applied to such problems as improving earthquake prediction and analyzing how ships capsize. It is also used to analyze the beating of the human heart and the pulse of brain waves. It would seem opportune for instructors in technology education and the humanities to examine how their disciplines reflect unpredictability, complex interdependencies, delays in responding to needs, transitions from one state to another, and the importance of a critical mass (ideas or materials) in producing and sustaining change. Technology surely must have some disorder inherent in the innovation process while alternative solutions are being sought and discarded as unusable, until the final and successful solution is found. Is there some way of determining the order within the disorder of technological innovation? If so, is it possible to quantify it? The point is, both technology education and the humanities could, together, become involved in the evolution of a new discipline. Is this too esoteric an undertaking for those in technology education? If the answer is affirmative, the profession should take immediate steps to hasten its demise.

The education of prospective technology education teachers, especially if they are to function in higher education, deserves reconsideration. The reconsideration should be along the line of examining the range of academic disciplines that comprise the students' curriculum. To be more specific, the course of study should include appropriate experience in the humanities.

This would be particularly relevant if there had been prior agreement with humanities professors that course content would include concepts with a potential link to technology—symbolization being an example. By all means, courses in philosophy should include reading and discussion of the works of writers such as Lewis Mumford, Francis Bacon, and Jacques Ellul—to mention but a few. Being conversant with the thoughts of these authors would broaden the base of understanding of technology educators.

SUMMARY

The implications (and suggestions) mentioned earlier have run along three related lines. So that there can be no misunderstanding, each of those three lines will be highlighted. First, the plea has been made for building the knowledge base of technology education. No longer can the profession claim a place in the curriculum on the basis of what the gurus proclaim is the truth. Technology education needs to define for itself a clear set of concepts, perhaps arranged in hierarchical order, that are the foundation on which curriculum content is derived. Were this to occur the profession would have some similarity in its curriculum from one school system to the next, much as math, physics, and chemistry enjoy. That similarity would not create a national curriculum, it would be a manifestation of having a delineated knowledge base.

Second, the suggestion has been put forth that alliances be formed with the various disciplines that comprise the humanities. Obviously, some of those disciplines have greater relevance to technology education and, therefore, those should be fostered. The purpose in forming the alliances would be to dispel the existing belief of a dichotomy between thought and action. If technology education is to thrive, it must demonstrate that thinking and the development of symbols are an integral part of the problem solving carried on in technology education laboratories. Those alliances have the potential to lead to mutually beneficial curriculum changes and instructional practices in the humanities as well as in technology education. Let us be realistic, however, and face the fact that those alliances will not happen if we wait for the people in art, history, philosophy, or math to approach us. They have recognized places in the curriculum which have an element of prestige attached to them, while technology education has not. It is the people in technology education who must take the initiative but in so doing, will need to have concrete proposals for cooperative action. Those proposals will require a conceptual rationale, clear courses of action, and a stipulated time frame. By all means, the proposals should invite modification from the humanities professionals after discussion.

The third suggestion might have been somewhat more implicit and, therefore, deserves explication. Only research will make possible the construction of a knowledge base. Only research will demonstrate ways in which the humanities and technology education are alike, or how they are different. One of the reasons people in technology education are perceived as doers rather than thinkers is that they do not conduct research, particularly of the kind that is done collaboratively with colleagues in other disciplines. Research might concentrate precisely on the similarity of thought processes in technology education and the humanities, or it might focus on the facility with which symbols are used or formed in the various disciplines. Whatever the nature of the research problems, it is hoped that the research design and data collection methods would not include survey techniques. There is nothing wrong with surveys, but they have been greatly overused in the conduct of research in technology education. Some of those surveys are acceptable, most are abominable; some deal with relevant topics, the preponderance of them are totally inconsequential. The stream of research that should be done must focus on the difference made in students' learning when they use tools and materials in a problem solving mode. If this question is not answered in such a way that technology education is shown to produce unique student outcomes, technology education will cease to exist.

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CHAPTER 5

Integrating Technology, Science, and Mathematics Education

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Not since the launching of Sputnik had proponents of educational reform been so vocal about the status of science, mathematics, and technology education in America as they became in the 1980s. Throughout that time period, one national report after another lamented the problems confronting science and mathematics education in this country. While our brightest students were on par with the rest of the world, the majority of children in America were losing interest in science and mathematics and falling behind their worldwide peers with respect to science and mathematics achievement (see, for example, Exxon Education Foundation, 1984; International Association for the Evaluation of Educational Achievements, 1987 & 1988; National Assessment of Educational Progress, 1989; National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, 1983; National Science Foundation and the U. S. Department of Education, 1980).

Sputnik had resulted in reform for science and mathematics education. This time, a battle cry rang out in the name of technology as well. The American public, the national reports on educational reform, and the different factions of the educational community spoke unilaterally on America's need for technological literacy in addition to the need for higher achievement in science and mathematics. Increasingly, science was being referred to in print as *science and technology*. Educational leadership in both the science and mathematics communities began to promote aggressively the idea of integrating technology into their respective curricula. Concurrently, the field of industrial arts education was undergoing a long called for transition to technology education—a paradigm shift that included a new name as well as new directions in the curriculum.

Specific events occurring throughout the 1980s in each of the three school disciplines of science, mathematics, and technology education provided for the first time a milieu for collaboration. In effect, proponents of reform in all three of these disciplines called for connections to the other two. As the 1990s unfolded, the time was ripe for curriculum reform efforts directed at formally integrating the three disciplines.

THE SCIENCE EDUCATION COMMUNITY

The science education community first began to champion the importance of technology in the curriculum with the Science, Technology, and Society (STS) movement. During the past two decades, STS curricula have gained visibility on college campuses, and to a lesser extent, in public schools (Kranzberg, 1991). While the architects of the STS movement and curricula have primarily been scientists, and the curricula tend to reflect more natural and social science than technology, STS proponents have long promoted the importance of technology in this mix. Publications from and conferences with those in the STS community dating to the 1970s began to develop an awareness of technology in the science community. The STS advocates pointed to the fact that science education was serving too small a percentage of the American population, and that a clear focus on technology was necessary to interest the majority of students in science. Rustum Roy (1989), one of the most active STS education proponents, suggested that "there should be radically new curriculum options which would combine much more hands-on practical learning—not far from present Technology Education curricula, but with more science" (p. 9).

The most visible push for the integration of technology into science education, however, came in the late 1980s with Project 2061, which was supported by the American Association for the Advancement of Science. This massive project, designed to span several decades, was described as "a three-phase plan of purposeful and sustained action that will contribute to the critically needed reform of education in science, mathematics, and technology" (American Association for the Advancement of Science, 1989, p. 3). Connections between science and technology are one of the salient features of their published report, entitled *Science for All Americans*, written by the Project 2061 staff in consultation with the National Council on

Science and Technology Education. Significantly, none of the council members were from the technology education community, yet their interest in technological literacy is evident throughout the report.

Project 2061 followed *Science for All Americans* with six panel reports, one of which was simply entitled *Technology* (Johnson, 1989). More than any other single document, *Technology* defined the rationale and structure of technology education for those in the science education community. Ironically, industrial arts/technology education professionals had worked for four decades to define the field, yet it was Johnson's brief report that both defined and legitimized technology education for science educators. For the first time, the science education establishment began to recognize the critical role that technology education could and should play in the schools. "Technology education should reveal the process of technology as it evolves from ideas to fruition. This can best be learned using laboratory experiences to augment classroom instruction. Likewise, such education should show how technology affects individuals and society" (p. 3).

Johnson (1989) not only defined technology education for the science community, he clarified the inseparability of science, mathematics, and technology:

> The sciences and mathematics are important to the understanding of the processes and meaning of technology. Their integration with technology education is vital. . . . Thus, a sound base in mathematics and biological, physical, and social sciences is vital to an understanding of modern technology. They should be part of technology education curricula, just as technology education should serve to bring additional meaning to the curricula of the sciences. (pp. 3–7)

In science education, another major initiative that recognized the role of technology in the curriculum, albeit to a lesser extent than did Project 2061, was the Scope, Sequence, and Coordination of Secondary School Science (SS&C) Project, directed by the National Science Teachers Association. *The Content Core: A Guide for Curriculum Designers* (National Science Teachers Association, 1992) provided a structure for science curriculum developers. The project developed a variety of different curriculum models along these guidelines and began to field test them around the country. One of the project's field test sites implemented an STS curriculum to test the viability of this approach. While the integration of technology into the curriculum was not as clear a goal for the SS&C Project as was the case for Project 2061, technology was at least present in the rhetoric of its reports.

All of this talk of reform in science education, coupled with seeming universal praise for the standards that mathematics educators had developed in the late 1980s (National Council of Teachers of Mathematics, 1989), led science educators to begin to develop science standards in the early 1990s. With support from the National Research Council, a National Committee on Science Education Standards and Assessment was formed, and they developed a series of "Working Papers" in an attempt to evolve a new set of standards for science education (National Research Council, 1992a, 1992b, 1993a, 1993b). This committee wrestled with their task, finding it difficult to agree on a set of standards, yet technology was addressed in each of the documents. The language of these standards generally referred to connections between science and technology, though the committee stopped short of describing anything too specific in this regard. These reports clearly suggested the science curriculum should deal with connections, relationships, and interactions between science and technology, while teaching *about* technology and engineering should be left to technology education (National Research Council, 1992a).

With all of this interest in the connections between technology and science education, the National Science Foundation (NSF) began, in the early 1990s, to solicit proposals actively from the technology education profession. Proposals of this type funded by NSF included Phys-Ma-Tech (Scarborough, 1993a, 1993b), The Technology, Science, Math Integration Project (LaPorte & Sanders, 1993), Integrating Mathematics, Science, and Technology Project (Loepp, 1991), and Project Update (Todd, 1992). These projects were manifestations of the interest that science educators had in technology education.

THE MATHEMATICS EDUCATION COMMUNITY

Concerned about the need for reform in mathematics education, the Board of Directors of the National Council of Teachers of Mathematics established the Commission on Standards for School Mathematics in 1986. The commission produced *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989), a document that had an immediate and resounding impact among mathematics educators as well as those in the broader arena of education. The curriculum portion of the *Standards*, as the document was commonly known, was "designed to establish a broad framework to guide reform in school mathematics in the next decade. In it a vision is given of what the mathematics curriculum should include in terms of content priority and emphasis" (p. v).

The curriculum *Standards* was divided into three sections: grades K–4, 5–8, and 9–12. It identified 13 curriculum standards for grades K–4, 13 curriculum standards for grades 5–8, and 14 curriculum standards for grades 9–12. The first four curriculum standards were the same for each of these three levels. They were Mathematics as Problem Solving, Mathematics as Communication, Mathematics as Reasoning, and Mathematics Connections. These and the other new mathematics curriculum standards were a very different way of defining mathematics curriculum. They communicated mathematics to educators in other disciplines in a much different light and served to open the door for collaboration with science and technology education. The language that appeared in the *Standards* run parallel to the rhetoric of technology education. Phrases such as "problem solving," "real world situations," and "connections to technology" could be found throughout it. While technology in the *Standards* generally referred to graphing calculators and computers, the language nevertheless provided a rationale of sorts for the establishment of curricular ties between mathematics and technology education.

The *Standards*, for example, was emphatic regarding the need for problem solving: "Problem situations that establish the need for new ideas and motivate students should serve as the context for mathematics in grades 5–8" (p. 66). The first standard on problem solving was even more specific:

> The curriculum must give students opportunities to solve problems that require them to work cooperatively, to use technology, to address relevant and interesting mathematical ideas, and to experience the power and usefulness of mathematics. . . . Real-world problems are not ready-made exercises with easily processed procedures and numbers. Situations that allow students to experience problems with 'messy' numbers or too much or not enough information or that have multiple solutions, each with different consequences, will better prepare them to solve problems they are likely to encounter in their daily lives. (p. 76)

The fourth standard, Mathematics Connections, even mentioned our field, among others, by name: "A topic such as measurement has implications for social studies, science, home economics, industrial technology, and physical education and is increasingly important teacher of these subjects" (p. 86). It is clear from the *Standards* that mathematics educators were not focusing on technology education, per se, as a sole collaborator in curriculum development, yet the language in the *Standards* was at the very least highly *encouraging* of such collaboration, perhaps for the first time. While the personal and professional connections between mathematics and technology educators were not yet in place when the National Council of Teachers of Mathematics' document was written, the authors nevertheless laid the foundation for those connections to begin.

In the early 1990s, tangible connections among mathematics and technology educators did begin to occur. One such example was Making the Connections: Mathematics/Science/Technology, sponsored by the Indiana State Department of Education in February, 1993. Billed as "The First Annual" conference on connections among the three disciplines, it attracted more than 1200 public school educators from around the state, the vast majority of whom were mathematics teachers. Significantly, more than a third of the presenters were from the technology education arena.

THE TECHNOLOGY EDUCATION COMMUNITY

With the name change from industrial arts to technology education, there came a renewed search for curriculum initiatives that would distance the new technology education from the image and curriculum of industrial arts. In the early 1980s, technology education proponents were championing the incorporation of social implications of technology into the curriculum as one of the key differences between the old and new paradigms. An increased emphasis on the so-called problem-solving method, making it more politically correct in the profession than the project method, was another one of the changes that occurred in the 1980s.

By the end of the decade, however, the field collectively seemed to lose some degree of interest in the social implications emphasis. It shifted its emphasis to the integration of technology education content and method with other school subjects. Many would-be technology teachers were concerned that in stressing the social implications of technology (as with STS), the field would surrender some or all of its commitment to the hands-on laboratory activities that had sustained the field for a century. The mix of technology, science, and mathematics was somehow more palatable to this contingency, perhaps because the curricular integration of these areas is more closely connected to the laboratory approach to instruction. That is, activities that integrate technology, science, and mathematics are essentially engineering activities, which, are inherently laboratory-based investigations with which technology teachers are quite comfortable. Thus, the idea of integrating these three areas seemed to catch fire among technology educators in the early 1990s.

While this was not really a new idea, (see, for example, Lux, 1984; Maley, 1973), it was a trend that gained increasing acceptance among technology educators as the 1990s unfolded. The discussions in industrial arts/technology education generated by curriculum development in the 1960s and 1970s, as well as the social implications discussions of the 1980s had, in effect, paved the way for the acceptance of the idea of integration with science and mathematics. Because of those earlier curriculum efforts, the field was ready for the approach to the study of technology that integration with science and mathematics offered. As evidence of the interest, more than 90 individuals participated in the first national workshop on the integration of technology, science, and mathematics at the annual conference of the International Technology Education Association (LaPorte & Sanders, 1992). A year later, the International Technology Education Association (ITEA) conference program included many presentations on the integration of technology with science and mathematics.

In the 1990s, technology education supervisors at the state and local levels began to fund projects that integrated these three areas. Increasing numbers of articles on this topic were published in the professional literature, and commercial curriculum materials surfaced, for the first time, at the 1993 ITEA conference. Most importantly, public school technology teachers began to be recognized for their innovative efforts along these lines. Greg Sullivan, Virginia's 1992–93 Teacher of the Year, for example, was a middle school technology teacher who had integrated science and mathematics into his technology education curriculum.

Parallel to these events was a $2 million initiative from the United States Department of Education. The Technology Education Act of 1990 resulted in funding for a series of technology education demonstration projects that integrated technology education with science and mathematics (Wicklein et al., 1991). These regionally distributed projects provided visible evidence of the integration of the three school subjects.

RESEARCH WITH IMPLICATIONS FOR THE INTEGRATION OF TECHNOLOGY, SCIENCE, AND MATHEMATICS

Hands-On Science versus Hands-On Technology

Hands-on is one of the hallmarks of technology education but the science community, like virtually every discipline taught in the school, also uses the term. Haury and Rillero (1992) stated that instructional approaches that "involve activity and direct experience have become collectively known as hands-on science" (p. 2). There are differences between hands-on science and hands-on technology that stem from basic differences in the nature of the two disciplines: Science is a study of the natural world whereas technology is a study of the human-made world. In both science and technology, there is an emphasis on problem solving. In science education, the problems in which the students are engaged are typically related to scientific laws and principles, knowledge that is already known by the science community. There is, therefore, a single, best solution to a particular problem (though there may be a wide variation in the methods used to arrive at the solution). Through working with problems, students can discover scientific laws and principles. They observe phenomena, formulate hypotheses, test their hypotheses through experimentation, and draw conclusions. Through this discovery, the learning is more engaging and interesting to the student and is therefore likely to be more permanent.

On the other hand, in technology education, as a study of the human-made world, students are engaged in solving practical problems. They design, construct, and evaluate their solutions. Just as there is no single best automobile, can opener, or building design, there is no single best solution to any of the problems that the students encounter.

In scientific investigations, it is essential that the particular variable under study be isolated from all the other variables that might have an influence on the outcome. For example, in conducting experiments on Newton's laws of motion, an air track might be used. The air track has a series of holes in it through which compressed air passes. This creates a nearly frictionless surface over which the vehicle being used to show Newton's laws can pass. The result is that friction has been rendered negligible. This isolation of variables is often the major challenge of scientific research.

The challenge in technological problem solving, on the other hand, is to recognize that a multitude of variables exists and that there is a complex interaction among them. Friction, for example, almost always has a negative effect on experiments in physical science, but friction in the world of technology can have both negative and positive effects. For example, a vehicle with minimal friction between the tires and the road surface requires less power to move it. An optimal level of friction is required, however, so that the vehicle can be adequately (and safely) guided along the road surface.

Another difference between hands-on science and hands-on technology is the amount of time spent doing it. Though no recent quantitative studies were found that addressed this question, it is safe to say that hands-on activity occupies the vast majority of the students' class time in technology education, but even in activity-based science classes, hands-on activity represents a relatively small proportion of class time. Bredderman (1982), for example, found that only 19% of the students' time was devoted to hands-on activity in what were termed "activity based [science] programs" (p. 41). Nonetheless, this was roughly twice the time devoted to activity in traditional science programs.

Science Research Relating to Hands-On Activities

Early research on the effectiveness of hands-on activities in science produced mixed results. For example, Kruglak (1953), in a study of college level general physics students, found that there was no significant difference between students who had a lab and those who did not in their performance on written physics achievement tests. Those who had the lab, however, achieved higher when it came to tests dealing with lab work.

During the 1960s, a considerable amount of federal money was invested in developing improved science curricula. The Biological Science Curriculum Study, the Earth Science Curriculum Project, and the Physical Science Curriculum Committee (1960) are examples of some of the noteworthy efforts. All of these utilized an inquiry approach and hands-on activities extensively, but by the end of the 1970s, most of these projects had disappeared. In reference to the situation at the elementary school level, Mechling and Oliver (1983) stated the following:

> The science classroom goes on—impervious to the findings of research. Except for a brief flirtation with inquiry or hands-on methodology in the 1960s, elementary science is taught pretty much as it always has been. Maybe the textbook is now in four colors, but the old read-recite-discuss way is as entrenched as ever. (p. 41)

This motivated Shymansky, Kyle, and Alport (1982) to conduct a meta-analysis of 34 studies that had been done on these new curricula. They concluded that students in these earlier hands-on programs had performed better, on a multitude of criteria, than had students in traditional, textbook-based programs. They also found that students' attitudes were more positive about the newer programs than about traditional programs. Apparently, the programs vanished due to other factors such as cost and the preparation time required on the part of the teacher. Instructional time was found to be an impediment in studies by Tilgner (1990) and Morey (1990).

Since the Shymansky et al. (1982) study, other meta-analyses have been conducted on the effectiveness of hands-on approaches to the teaching of science. Bredderman (1985) synthesized 57 studies of the use of hands-on activities and inquiry-based teaching, encompassing 13,000 students in over 1,000 classes. He concluded the following:

> It appears that the programs' design to encourage the use of laboratory science, starting in the elementary school years, does in fact result in improved student performance in a number of valued curricular areas. Based on the available research evidence, it also appears that the use of inquiry based programs increases the amount of student laboratory activity and decreases the amount of teacher talk in the classrooms. (p. 586)

Two of the valued areas that Bredderman's meta-analysis addressed were achievement and motivation.

Cotton and Savard (1992) reviewed 44 studies that were conducted on intermediate level science and mathematics instruction. They concluded that activities such as "student projects and presentations," and "field trips and laboratory experiments" have a positive effect on achievement and affective outcomes (p. 9). In addition they concluded that activity-based instruction is particularly effective with remedial students. They cautioned that activity-based instruction may be best used in combination with some of the traditional methods such as lecture, discussion, and demonstrations.

Hands-on activities have also been shown to have a positive effect on the ability of students to solve problems. Glasson (1989) conducted an experiment with ninth grade physical science students on a three-week unit on simple machines. He compared students taught by demonstrating science experiments to students actually doing the experiments. He found that the physical manipulation of laboratory equipment was not a factor in improving declarative knowledge (factual and conceptual), consistent with four other research studies he cited. Students in the hands-on group, however, performed significantly better on the procedural knowledge (problem-solving) test used in the study. He concluded that all students, regardless of reasoning ability, benefited from hands-on laboratory instruction. He also concluded that hands-on activities "promote peer interaction where students are free to argue, make mistakes, and challenge each other" (p. 129).

Overall, one can conclude that hands-on science is, indeed, more effective than traditional approaches in at least two principal ways. First, it increases student achievement, especially if the evaluation instruments measure more than the mere memorization of facts (see Brooks, 1988; Mattheis & Nakayama, 1988; Saunders & Shepardson, 1984). This is perhaps why Kruglak (1953), a study mentioned earlier, found that the laboratory component of a physics course made no difference in student achievement on written tests. Second, hands-on science tends to improve the attitude of students toward science (see Jaus, 1977; Kyle, Bonnstetter, Gadsden, & Shymansky, 1988; Kyle, Bonnstetter, McCloskey, & Fults, 1985;

Rowland, 1990). One could argue that a student's attitude toward science is an essential prerequisite to learning the subject matter.

Even though there is mounting research evidence about the value of hands-on activities, the science community has a long way to go before this method becomes a significant part of instruction. In a large-scale study reported by Weiss (1987), lecture/discussion was found to be the typical teaching method used in science classes. Hands-on activities were more predominant in elementary school than in the secondary level (51% of the lessons versus 43% in middle/junior high and 39% in high school). The vast majority of teachers believe that hands-on activities are more effective than traditional methods. Yet, ironically, Weiss found that hands-on activities were used to a lesser extent by teachers polled in this study than they were in a comparable study reported in 1977.

Mathematics Research Relating to Hands-on Activities

A significant amount of research has been conducted in an attempt to determine the effectiveness of hands-on activities in mathematics. Manipulative activities, as they are referred to by math educators, became popular in the 1980s, and there is ample research to suggest that manipulative activities are, in fact, an effective way of teaching mathematics concepts. Variables such as achievement, long term retention, teacher and student attitudes, assessment strategies, and differential impacts upon varying ability students are among those that have been studied with respect to manipulative math activities. Although manipulatives have been used more at the elementary grades than in later years, the research spans the kindergarten through college continuum.

Lenoir (1989) analyzed 45 studies of the effects of manipulatives in mathematics instruction from kindergarten through college. He concluded that students in grades 6–9 who used manipulatives in learning measurement skills demonstrated greater achievement than those who did not use manipulatives. Moreover, those students retained more after one to four months with respect to measurement and other mathematics concepts than those who did not participate in manipulative activities. Manipulatives have been particularly effective and extensively used by teachers in the elementary levels. This is consistent with Piaget's work, which suggests that children under the age of 11 are not able to think in abstractions. Concrete examples are, therefore, particularly helpful to them.

A variety of findings supportive of hands-on activities in mathematics have been discovered by a number of different researchers. Among those findings are the following:

1. Simon (1991) conducted a descriptive study of 80 third and fourth grade students who received manipulative based mathematics instruction and found students to be more "focused" during manipulative lessons. Both the teachers and students in Simon's study believed that manipulatives enhanced the understanding of mathematics. Simon also concluded that it is practical to incorporate manipulative activities into the mathematics curriculum over the course of a full year.
2. Sigda (1983) developed and evaluated manipulatives for teaching multiplication to third grade students. The treatment presented content via a *sequential-modal* approach which included manipulatives, pictorial information, and symbolic representations. Sigda found that the use of the sequential-modal approach resulted in significantly greater acquisition and retention of the basic multiplication combinations, array translation skills, and skills in operation identification among the third grade students.
3. Canny (1984) studied the relationship of manipulative instructional materials to achievement in fourth grade pupils. Students who used manipulatives for the introduction and reinforcement of concepts scored significantly higher on two achievement tests than did the control group using the textbook activities.
4. McCoy (1989) looked specifically at the perceptual preferences of mathematically deficient elementary school students. Comparing students in need of remediation with average or above average math students, McCoy found the former group to prefer a kinesthetic mode of instruction and concluded, "the results of this study strongly support the use of concrete manipulatives and related activities" (p. 9).
5. Prigge (1978) and Kipfinger (1990) each studied the use of manipulatives to teach geometry concepts to sixth grade students. Prigge used solid objects to aid with instruction and found positive significant effects for low ability students, but no effects with high ability students. In a similar study, Kipfinger found statistically significant results in favor of the manipulative method of instruction for geometry.

While manipulatives have been common in elementary school mathematics, their paucity in middle schools led to a study by Tooke, Hyatt, Leigh, Snyder, and Borda (1992). They interviewed 30 teachers from grades 4 through 8 to assess their attitudes regarding the use of manipulatives and to find out why few middle school teachers made use of manipulatives. Two general findings emerged. First, middle school teachers had generally not received training with manipulatives and were, therefore, uncertain as to how to make use of them in instruction. Second, teachers felt manipulatives were simplistic and thus inappropriate for students above the fourth grade level. Teachers said things such as "manipulatives were too far beneath them," and students in fifth grade "needed" abstract teaching. The researchers noted, however, that certain manipulatives such as Geoboards and Mira were designed for middle school students.

Certain logistic problems that surfaced in their study were reminiscent of those confronting teachers today who wish to integrate mathematics with technology education. After the fourth grade, for example, teachers felt the pressure to complete the math curriculum left too little time for manipulatives. Another compounding variable mentioned was the lack of support for the purchase of manipulatives for middle school students.

Despite these impediments, manipulatives have been used at times in middle and high school mathematics instruction. Meira (1992) presented eighth grade students with physical devices: a winch, a device with springs, and a computerized input-output machine. The intent of the study was to determine the role that designing (which was viewed as a manipulative) played in mathematical sense making. Meira found that graphic representations on paper provided the material basis for mathematical activity. These representations were not simply recalled, but rather were reconstructed with regard for the physical setting of the activity. They were, therefore, important to the student's ability to make mathematical sense of the problem at hand.

Balka (1983) experimented with mathematics manipulatives to teach computational skills to mildly handicapped students in a high school pre-vocational program. He found computational achievement increased on all subtests and composites except on the simplest arithmetic test. These findings led Balka to conclude that the use of manipulatives improved the computational skills of slow learners. He also found that manipulatives were motivating for students and resulted in increased class discussion.

Technology Education Research Relating to Hands-On Activities

As with the programs that preceded it, hands-on learning is the hallmark of technology education. It exemplifies the thinking of noted experiential philosophers and theorists such as Pestalozzi, Rousseau, and Dewey. Unfortunately, very little research has been done to show the relationship of hands-on activities to cognitive learning in technology education. The history of the profession offers some explanation for this void. Though there was much literature generated to support the theory that activities should serve as the means to an end and that learning should include the cognitive domain, actual practice in earlier programs was principally focused upon developing skill in the use of tools and machines (Dugger et al., 1980). In other words, the hands-on activities were not the means to cognitive knowledge, they were often the end itself. Even in contemporary programs, if one believes that technology is thoughtful doing (Towers, Lux, & Ray, 1966), then a focus upon activity, or doing technology, is understandable and defensible.

The lack of research in the connection between activities and cognitive knowledge compelled Korwin and Jones (1990) to conduct a study to determine if cognitive knowledge increases when technology-based, hands-on activities are used to supplement regular classroom presentations. Their subjects were eighth graders and the instructional unit was geodesic domes. They found that the hands-on activity of actually building a geodesic dome improved performance on a cognitive achievement test about the instructional unit. They did not find any difference, however, between the two groups in retention of knowledge after two weeks. Korwin and Jones made an important point about the lack of research in this area. It is quite likely, however, that the findings reported earlier on the value of hands-on activity in increasing cognitive understanding in mathematics and science would be applicable to technology education. Nonetheless, more research is certainly needed in this area.

With the exception of the Korwin and Jones study, most research on activities has been at the elementary level and has dealt with the efficacy of technology activities in promoting understanding in other subjects. Early research efforts by Champion (1966), Downs (1969), Logan (1973) and Pershern (1967) showed that industrial arts activities incorporated into science and/or mathematics instruction enhanced achievement, motivation, or both. More recently, Kowal (1985) compared elementary school mathematics and science students who were taught using constructional (industrial arts) activities versus those who were taught without such activities. He found that students were more motivated in mathematics classes that incorporated the activities than they were in social studies classes. Also, motivation was higher in mathematics classes taught using the activities than in traditionally taught classes.

Brusic (1991) examined fifth grade students' achievement and curiosity relative to a science unit in which technology activities were integrated. She also investigated whether students' curiosity about the unit prior to studying it was related to their achievement. She found that the group that was engaged with the technological activity had a significantly higher level of curiosity than the control group. She found no significant differences in science achievement. Brusic concluded that the integration of technological activities with science instruction may positively affect students' curiosity, but may not enhance or deter from their science achievement. Hence, the science-technology linkage shows promise as a useful method of promoting greater student curiosity without negatively affecting their achievement.

Though not done by researchers within the field of technology education, three studies exemplify direct implications of the value of the hands-on approach and content of technology education relative to science and mathematics. Cohen (1992) cited research showing that the majority of late adolescents and adults in the United States function at Piaget's concrete operational level rather than at a formal (abstract) operational level, refuting the Piagetian notion that the transition to formal thought occurs at about age 11. He also cited evidence that science is taught, for the most part, abstractly. From his study, he concluded that most middle school level students and a significant portion of high school students are not able to understand science concepts. It is, therefore, imperative that science be taught in a concrete manner for most students. The applied nature of most technology problems certainly offers potential in providing the concrete learning experiences about which Cohen wrote.

A second study with implications for technology education was done by Hoffman (1989), a German science educator. Her work was motivated by a belief that interest is the most important requisite to learning and that disinterest in science is an international phenomenon. Science programs must, therefore, be restructured so that they increase interest. In her study, she investigated students' interest in specific kinds of activity that relate to science and then asked them to compare the amount of time spent doing that kind of activity in science classes. She found that "Testing something, taking a device apart or putting it together" was ranked 2nd among females and 1st among males across nearly all grade levels in terms of interest. Among females, this was ranked 10th of the 12 forms of activity actually done in the science class. Among males, it ranked 11th. "Inventing something, designing a device" was ranked 6th among females and 4th among males at the 10th grade level in terms of interest, yet it was ranked last in terms of the students' perception of how often they were allowed to engage in such activity in science class. Hoffman also found that the context in which science is studied is important. For example, males tended to be equally interested in learning about pumps in either the context of an artificial heart or in transporting petroleum products. Females preferred, however, the artificial heart. Hoffman's study shows that students have a keen interest in what happens in technology education, yet they actually have little opportunity to do it, at least in science class. Her work also suggests that there are gender differences regarding the technological contexts.

Finally, White (1979), an Australian science educator, synthesized literature on memory recall. He contended that long term memory related to the understanding and recall of science concepts can be enhanced through the development of personally involving episodes. He argued that the typical science lab does not produce such episodes and lacks any relationship to the real world. As a solution, he suggested the following:

> Kinematics experiments . . . might be better done with people, bicycles, and cars than solely with trolleys and airtracks; experiments on refraction might involve swimming pools rather than glass blocks; and electricity might be better studied with house fuses, switches and meters or with torches in their commercial cases than with rheostats and potentiometers. As well as providing more recallable and useful generalised episodes these changes could make students see physics as a more relevant study in their lives than they do now. (p. 386)

White (1979) suggested that three types of experiments should be considered in physics. The first type is "the unusual experiment which engages the emotions through being odd, dramatic, beautiful or puzzling" (p. 387). A second type links "school subject matter and daily life . . . providing experiences which will be called into play in making subsequent information comprehensible" (p. 387). A third type involves "true problem solving" (p. 387). The integration of technology, science, and mathematics seems quite clear in White's conclusions.

Though fewer in number than the studies conducted by the science and mathematics community on the use of hands-on activities, the results of research on the use of technology activities to augment science and mathematics instruction are remarkably similar. Like hands-on science and mathematics, hands-on technology integrated into science and mathematics classes tends to improve motivation (or curiosity) and achievement, but a key question remains unanswered. Does hands-on activity, simply by itself, account for the improvement? Nearly all the studies conducted by the science and mathematics community compared hands on to traditionally taught classes. There was little evidence that one hands-on method was superior to another. Most of the studies done by technology educators were conducted years ago and even the most recent studies did not truly engage students in technological problem solving as it is thought of today. For the most part, they were simply constructional activities. Whether or not technology problem-solving activities uniquely contribute to the motivation and achievement in science and mathematics is unknown. Yet, there is at least some research evidence from outside the field that suggests that the concrete, real world nature of the programs may be particularly suited to the needs and interests of students to augment their understanding of science and mathematics.

CURRENT NOTIONS OF INTERDISCIPLINARY INSTRUCTION

The notion of the teacher as the fountain of knowledge pouring wisdom into the minds of youngsters runs contrary to constructivism and the recent work of cognitive psychologists. Learning is increasingly viewed as mediated by context. One of the criticisms leveled by the *High School* report was the unnatural separation of content that had occurred in the public schools. As Boyer (1983) wrote on the committee's behalf: "While we recognize the integrity of the disciplines, we also believe their current state of splendid isolation gives students a narrow and even skewed vision of both knowledge and the realities of the world" (pp. 114–115).

Schools have made considerable headway on the task of amending this situation since the early 1980s when Boyer made his observations. The middle school movement, which began more than two decades ago and has gained a great deal of momentum in recent years, is predicated on interdisciplinary teams and a core curriculum (Vars, 1987). Regrettably, technology education is almost universally omitted from the teams, which are generally comprised of the "academic" subject areas: language arts, social studies, science, and mathematics.

At the elementary level, programs such as "Whole Language," "Writing Across the Curriculum" and "Math Their Way" have been very successful at breaking down artificial barriers among the traditional content areas. High schools, under the tight reins of standardized tests and college entrance requirements, have been particularly slow to cross over the traditional curriculum boundaries, but they too are exploring options along these lines. Thematic instruction, in which teachers from different disciplines relate lessons to a pre-determined theme, has served as a popular means of integrating content at all levels of education.

In light of contemporary research on cognitive theory, educators in general and the science and mathematics educators in particular have come to realize the limitations of teaching in relative isolation. Many now feel that science and mathematics taught as abstractions divorced from reality are of relatively little use. As Langbort & Thompson (1985) articulated, "An important instructional principle, strongly validated by recent educational research, is that children learn science and mathematics more effectively when they can concretely connect experiences with principles they are studying in various subjects" (p. 8).

SOME RECENT MODELS OF CURRICULUM INTEGRATION

A substantial number of models for integrating technology, science, and mathematics have been developed and implemented. In addition to the relatively recent work being done to integrate all three of these areas, the Science, Technology, and Society (STS) movement and the Teaching Integrated Math and Science Project (TIMS) are notable examples of integration. The STS movement got under way more than two decades ago as science educators began to recognize the interconnected nature of science and technology. As Gallagher (1971) stated, "To make an unnatural separation of the two, teaching only a so-called basic science, excluding technology, leaves learners with an unrealistic picture of the workings and results of the scientific enterprise" (p. 333). In the early 1980s, STS advocates were successful in convincing the National Science Teachers Association to develop a policy statement promoting the implementation of STS (Bybee, 1991). Research has brought to light a number of positive outcomes of STS programs (see, for example, Yager, 1988a; Yager, 1988b; Yager, Blunck, Binadji, McComas, & Penick, 1988).

The Teaching Integrated Math and Science Project (TIMS) at the University of Illinois at Chicago has been developing curriculum materials that connect mathematics and science since the late 1980s. In 1991, the National Science Foundation (NSF) awarded the project an additional $4.2 million to develop a comprehensive integrated math/science curriculum for grades K–6. To date, the project has published more than 70 different activities that utilize this approach.

The Research and Experimentation course, outlined in the *Maryland Plan* (Maley, 1973), was one of the earliest efforts to integrate what was then industrial arts content with science and, to a lesser extent, mathematics. This ninth grade class was essentially a science experiment conducted by students in an industrial arts facility. Few industrial arts educators were ready to adopt this approach, though many of Maley's ideas resurfaced two decades later after the formal transition to technology education. Maley's work later led to *Math/Science/Technology Projects for the Technology Teacher* (Maley, 1984). In an effort to pull together content from all three disciplines, Maley had his students construct models of technological artifacts (e.g., a water-wheel, block and tackle, hydraulic elevator, etc.) and then identify the scientific and mathematical principles connected to the artifact. Maley was among the first to recognize the importance of formally integrating science and mathematics into the technology curriculum. He noted the following in the "Introduction" to the monograph:

> The current emphasis on mathematics and science provides a rich opportunity for industrial arts/technology education to establish itself as an important partner in contemporary education. . . . The impossibility for teaching any technological development to any extent within a single discipline makes a persuasive case for a partnership relationship as well as a requirement for integration of subject matter. Industrial arts/technology education has, within its content and methodology, a prime vehicle through which the subjects of the school are brought together for the purpose of meaning, understanding, and relevance on the part of the learner. (p. 7)

In the Fall of 1984, the "Resources in Technology" section of *The Technology Teacher* began to include a "Math/Science/Technology Interface" subheading. The idea was beginning to catch on in the field. In the waning years of the decade, a handful of innovative technology teachers began to incorporate science and mathematics into their curricula and/or work with science and mathematics teachers in their schools. The idea of integrating technology, science, and mathematics really seemed to take hold as the '90s came in, and a flurry of activity in this regard began to occur. Activities and curriculum development began in earnest at both the elementary and secondary levels.

FUNDED PROJECTS

United States Department of Education

In 1991–92, the United States Department of Education sponsored four regional demonstration projects that were intended to develop models for the integration of technology, science, and mathematics (Wicklein et al., 1991). These projects were among the first to fund project directors from the field of technology education. They enabled the directors to begin to develop materials that would integrate technology, science, and mathematics at both the middle and high school levels. Four different regions were represented: mid-America, Northeast, far-Northwest, and the Appalachian regions. The latter project resulted in curriculum materials that became commercially available upon completion of the project.

Elementary School. Content at the elementary level tends to be more integrated than at the secondary level. The Mission 21 Project sought to capitalize on this with a project that integrated technology-based problem solving for the elementary grades. In 1985, The National Aeronautics and Space Administration funded researchers at Virginia Polytechnic and State University to develop these curriculum materials for grades 5–6. Additional phases were subsequently funded: grades 3–4 in 1988, grades 1–2 in 1989, and preschool–K in 1992. The materials used thematic technology problem-solving activities to integrate mathematics, science, social studies, and language arts. The Level III (grades 5–6) materials, for example, were organized around four themes: Communication, Energy and Matter, Invention, and Space Colonization. All materials were field tested extensively throughout Virginia and the materials, including books carrying each of the theme titles and a teacher's resource book, were commercially published in 1992 (Brusic & Barnes, 1992).

In 1992, the National Science Foundation funded another major project directed primarily at the elementary grades, but extending into the middle grades as well. The four primary objectives of Project Update were the following:

1. Develop curricular materials for grades K–8 that integrate technology, science, and mathematics reflecting a design and technology/engineering education approach;
2. Establish a clearinghouse to collect and disseminate integrated TSM materials;
3. Initiate collaborations with scientists, engineers, and technologists in the local community; and
4. Disseminate the work of the project through *Ties Magazine*. (Todd, 1992).

Middle School. The National Science Foundation provided substantial funding for two middle school projects focused on technology integration. The Technology, Science, Mathematics Integration Project, funded from 1991–1993, developed 15 activities designed to require the application of science and mathematics to solve technological problems (LaPorte & Sanders, 1993). It was believed to be the first attempt to develop comprehensive curriculum materials designed to encourage teachers in all three areas to work together. Though the middle school movement began to make great strides in terms of getting teacher teams working together, the technology teacher was systematically divorced from those teams. The

Technology, Science, Mathematics Integration Project materials required the technology teacher to be on the team with the science and math teachers, thereby facilitating a coordinated effort among all three teachers. Upon completion of the project, the activities were commercially available for use in middle schools.

The approach followed by the Technology, Science, Mathematics Integration Project was to develop technological problem-solving activities that would take perhaps one to three weeks to implement. This approach allowed teachers in each of the three areas to incorporate the activities into their existing curricula rather than to restructure their entire curricula. It was believed this would make it easier for the majority of teachers to attempt a technology, science, mathematics integration approach in their classrooms (LaPorte & Sanders, 1993).

There was also a perceived need for an entire curriculum that would integrate technology, science, and mathematics in the middle school. In 1992, the National Science Foundation funded the Integrated Mathematics, Science, and Technology Project (IMaST). The focus of this project was developing and field testing materials centered around the topics of biotechnology, manufacturing, and forecasting for seventh grade students. The project hoped to find solutions to some of the problems that impeded systemic change with regard to the implementation of integrated curricula.

High School. Several high school models emerged in the early 1990s as well. Technology teachers in Conroe, Texas undertook a thematic Space Simulation project at The Woodlands High School. The project, which received funding from the National Air and Space Museum, capitalized on America's fascination with space. It rallied the entire school around a space simulation, which they constructed in the technology education facility. Teachers throughout the school coordinated instruction with the project. Science experiments, for example, were designed by students and conducted during the several days that students spent physically isolated inside the "space station." The project resulted in, among other things, publication of *Space Simulation* (Bernhardt & McHaney, 1992), which challenged other schools to "design, build, operate, and evaluate a habitat for human beings in a hostile environment for a period of not less than 24 hours" (p. xi). The teachers involved even formed an international association to facilitate implementation of this type of activity in other schools around the world.

Phys-Ma-Tech (Scarborough, 1993a, 1993b) was another example of a high school project, funded by the National Science Foundation, that sought to develop models depicting physics, mathematics, and technology teachers working together at the high school level. Phys-Ma-Tech utilized 15 teachers in five schools to develop and test various integration models. Among the benefits noted by Scarborough (1993b) were increased enrollments in physics and technology, higher test scores, and new teacher interest and support for the concept.

IMPLICATIONS FOR TEACHER EDUCATION

Technology Teacher Education

One can argue about which came first, technology or science, as well as what dependencies there have been between the two disciplines in the past (see, for example, DeVore, 1987). These arguments are important in establishing the foundation, lineage, epistemology, and scope of technology, but the interdependencies of technology, science, and mathematics in today's world are irrefutable. From a technology perspective, it seems moot to argue that a strong, conceptual background in science would not enhance one's ability to solve technological problems and to better understand the human-made world.

Logically, as the field moved away from trade-based courses and an emphasis on skill in the use of tools, it seemed that more attention would be given to assuring that prospective teachers had a strong background in science and mathematics. Apparently, this is not the case. Finch, Schmidt, Oliver, Yu, and Wills (1992) analyzed the transcripts of recent teacher education graduates in agriculture, business, home economics, marketing, technology, and trade and industrial education. In science credits, technology graduates completed an average of 9.3 semester hours, ranking only fourth among the six teaching specialties in the study. Only business (8.8) and marketing (7.6) required fewer hours. Fewer than one fourth of the technology graduates earned 12 or more semester hours in science. Most of the science semester hours that the technology graduates completed were in biology (3.9). Physics and astronomy courses were next, with an average of 3.1 semester hours. An average of 1.2 semester hours were completed in chemistry.

Technology education majors ranked fourth, as well, in the amount of mathematics and computer science course work completed, averaging 7.6 semester hours. Home economics and trade and industrial education were the only groups that averaged fewer semester hours (6.7 and 7.5 respectively). Only 9.3% of the technology graduates earned 12 or more hours in mathematics and computer science, the lowest among the programs studied.

These are startling statistics. First, with the possible exception of agricultural education and its intimate dependence upon the biological sciences, it seems logical that technology education graduates would have completed more science credits compared to graduates of the other programs in the Finch et al. study. At least one would assume that the semester hours would be greater than those completed by trade and industrial education students. This was not the case. The credit hours completed by technology graduates in mathematics and computer science are somewhat less surprising, relative to the other teacher education graduates. For example, business students need a solid background in mathematics because of the importance of quantitative methods in their field.

Second, the sheer number of science and mathematics semester hours completed are disconcerting. Virtually all colleges and universities have had requirements for course work in the basic disciplines (mathematics, natural science, social science, and humanities) from their inception. In the recent decade, the perceived value of such course work has increased, resulting in corresponding increases in the semester hours required, through what are often called *core requirements* (see Lynch, 1990). As Finch et al. (1992) suggested, it is quite likely that the courses in science and mathematics completed by technology education graduates were simply the minimum number required by the institution for graduation.

On the other hand, it is somewhat encouraging that an average of 3.1 hours in physics and astronomy were completed, considering the close relationship between the content of existing technology education curricula and physics principles. This relative predominance of physics was greater by far than the average number of hours completed by graduates of the other programs in the study. The fact that most of the credits in science earned by technology education graduates were in biology might also be construed in a positive light. This is potentially an essential first step for teachers to deliver instructional programs in biotechnology, as some in our field are promoting (see, for example, Savage, 1991). Yet it could also be that the predominance of biology course work is due to the perception that biology is the "lesser of the evils" and easier. Moreover, one course in basic biology may not have any real value in implementing a biotechnology program.

There are a myriad of reasons for the rather limited background in science and mathematics among technology teacher education graduates. As technological knowledge increases and the field becomes broader, there is a tendency for course requirements in the program to increase. Courses required outside of the program may be seen as an impediment to assuring that the student has a sound grounding in the fundamentals of the field.

Many technology education majors are transfers from other programs including those of the engineering and engineering-related curricula. This phenomenon seems to be particularly prevalent in land grant universities where engineering is frequently the predominant curriculum. A major reason for the transfer decision is the lack of success the students have experienced in calculus and calculus-based physics, and foundation courses that serve to "weed out" students in engineering. Consequently, they arrive with a certain disdain for science and mathematics in general when they enter the technology education program.

Other students are attracted by the emphasis on practical, hands-on doing that typifies most technology teacher education programs. Perhaps through interest and success in technology programs in their earlier schooling, they seek more of the same at the college level. Perhaps they have already been turned off to science and mathematics through their earlier educational experiences. Consequently, they seek a curriculum at the college level from the perspective of what the curriculum does *not* require (a lot of science and mathematics) more than what it does include.

Technology teacher education programs have been waging a battle for a decade or more to keep enrollments at a level whereby they can continue to exist and supply teachers for the public schools. Many have lost that battle, especially in recent years. To some extent, the dearth of science and mathematics required of technology majors may be motivated by self-preservation. If the science and mathematics requirements are similar to the requirements of engineering, unsuccessful engineering students will not be attracted, nor will students who experienced failure in science and mathematics at the secondary level. Likewise, those who find practice more appealing than theory will not be motivated to enroll in a program that places theory in a prominent position. If the technology student and the technology teachers in the public schools have developed a disinterest or even a disdain for science and mathematics, the challenge of implementing programs that integrate the three disciplines is great indeed.

Even if discipline integration does not occur, it is still essential that the technology teacher exit the teacher education program with a solid background in science and mathematics if the ideals of technology education are to be realized. In the days of earlier programs in which students built projects following plans prepared by the teacher, knowledge of science and mathematics were only minimally applied. In the present era, where technological problem solving is the very core of the program, such knowledge is essential. Without it, a situation in which students try to solve technological problems using only the knowledge with which they entered the class will prevail. When these problems are solved, the teachers, like the students they teach, will continue to have no idea of why solutions did or did not work.

Optimal solutions to problems such as building bridges, solar collectors, model submarines, and hydraulic robots, as well as the venerable CO_2 car, all rely heavily upon science and mathematics. Though students can solve these problems in the absence of science and mathematics without them, the potential for learning is dramatically decreased. This circumstance has led some technology education teachers to incorporate more science and math instruction into their technology classes. This approach to content integration requires technology teachers to be not only well grounded in science and mathematics, but also to possess the skills necessary to put the knowledge into teachable terms so students may effectively apply it. Most importantly, teachers must also be motivated and excited about the potential benefits of this approach for it to work.

The potential for both technological and scientific misconceptions abounds. Clearly, there are many voids to fill and chasms to cross if content integration is to be realized. To do so necessitates more than just requiring more credits in science and mathematics among prospective technology teachers.

Science and Mathematics Teacher Education

The dependence of technology on science and mathematics in solving technological problems was delineated in the previous section. Likewise, it seems foolish to think that one's ability to hypothesize about and understand natural phenomena would not be enhanced through an understanding of technology and real-world applications. In fact, the idea of practical application runs consistently through the new mathematics (National Council of Teachers of Mathematics, 1989) as well as through the science standards that are currently under development. A problem exists, however, because although the technology teacher may have had minimal course work in science and mathematics, the course work among science and mathematics teachers in technology is virtually nonexistent. While technology teachers typically have studied science and mathematics courses every year from 1st through 12th grades, it is highly unlikely that science or mathematics teachers have *ever* had a technology course.

According to Johnson (1993), there is only one institution in the country that requires all prospective teachers to complete course work in technology. Practical problem solving for science and mathematics teachers is often limited to the illustrations of technology in the textbook and "story problems" at the end of each chapter. Only those science and math teachers who have had real-world experience through previous employment or are exceptionally creative will bring the technological world outside the school into their teaching.

Providing a technology knowledge base among science and mathematics teachers is difficult because of impediments that are parallel, but often opposite, to those that one faces in providing a science and mathematics base for technology teachers. Both science and mathematics teachers are ingrained in a culture that seeks to predict and explain phenomena. In science classes, every effort is made to control the environment of scientific experiments, reducing causal explanations of phenomena to the single variable under study. Likewise, the mathematics teacher is acculturated, to a great extent, to the idea that there is a single, right answer to mathematical relationships. Just as the technology teacher may have become interested in technology because of practice, science and mathematics teachers may have chosen their fields because of their affinity to the purity and orderliness of theory. Technology, with its multitude of "right" answers and often infinite numbers of variables that interact with one another, may simply not be of interest to them. Just as the technology teacher may be most interested in the hands on, the science teacher, and especially the mathematics teacher, may find "minds on" most attractive. This dichotomy is well articulated in C. P. Snow's (1959) *The Two Cultures and the Scientific Revolution.*

The Challenge of Preparing Teachers for TSM Integration

Whether the disciplines of technology, science, and mathematics are totally integrated or the respective teachers simply integrate content within the classes they teach, a change in the professional education of teachers is essential. One of the main goals of universities is the generation of new knowledge. Virtually all reforms in educational practice have roots in higher education and the research that is generated there, yet the higher education "academy" is the most rigid and slowest component to change. There is even some irony that prevails. For example, the educational community has decried lecturing as one of the least effective methods of teaching, yet, it is almost the *sine qua non* of teaching in higher education. Likewise, and researchers in technology education promote new curricula, yet the courses they teach often do not reflect the ideas they are promoting to others.

Integration of subject matter at the elementary level comes almost naturally. With the typical "one teacher teaches all" model, the elementary teacher would almost have to make a concerted effort to avoid integration. As the grade level increases, however, integration becomes more difficult. Walls are formed around the disciplines. In higher education, the disciplines are separated into discrete buildings, both literally and figuratively. Often, the faculty in a particular program have little idea about what the students learn in the courses they take outside of their own department. In addition, the content of these courses varies significantly across different sections of the same course and from one semester to another. These factors, as well as the sheer number of university faculty, make integration at the college level a massive challenge, indeed.

Even within colleges of education, there may be minimal knowledge among the faculty regarding what is learned in the professional courses their students take. The problem is no doubt worse in programs where the technology students are enrolled in one college (e.g., college of technology) while taking professional courses in another (e.g., college of education). The Holmes Group (1986) model of requiring a degree in the discipline in which a student expects to teach may also exacerbate the problem.

The structure, communication network, and magnitude of the higher education establishment provide sizable obstacles to even minimal approaches to integration of subject matter. Even if the discrete courses that prospective teachers take outside their discipline of choice are consistent over time and faculty are knowledgeable about their content, the void between the courses taken and the nature of how the discipline is taught in the public schools remains great. Yet, the void must be filled if the notion that "we teach as we are taught" is a truism.

Toward a Teacher Education Solution

If technology, science, and mathematics educators are committed to linking their disciplines more closely, then a change in the manner in which teachers are prepared must be forthcoming. Teachers of science and mathematics must have formal, relevant course work in technology. So-called "general technology" courses have been developed at the college level at several universities. Such courses have evolved from a variety of influences, including the Science, Technology, and Society (STS) movement, engineering programs that saw a need for the general public to become more informed about technological issues, social science faculty who recognized that technology is increasingly becoming a significant social force, and philanthropic foundations that recognized the pervasiveness of technology. Of course, technology teacher education programs have been involved in these efforts from the outset.

By and large, these general technology courses, even when offered by technology teacher education programs, have been studies *about* technology rather than studies *doing* technology. Perhaps this is a good first step toward the recognition of technology as an important area of study, but for teachers interested in integrating their discipline with technology, they fall well short of the mark. What is needed are educational experiences in which *doing* technology is the *modus operandi*, but doing technology by itself is also insufficient. As Lux (1984) stated, "Practice is an essential but not sufficient characteristic of technology. That is, with the practice must go the theory of that practice, otherwise it is mere doodling. And theory without practice is mere intellectual exercise" (p. 18). To meet this goal, a commitment to a comprehensive, articulated, laboratory-based educational experience is needed. The model of delivering instruction through large group lectures, thereby generating significant student credit hours for the program with minimal resources, will not work. Science and mathematics teachers need to *do* technology in the same way that aspiring technology teachers do it in our programs.

Just as science and mathematics teachers need a quality experience in technology, the reverse is also true. As a first step, technology faculty must become knowledgeable about the specifics of the courses that their majors are required to take in science and mathematics. Conversely, the faculty in science and mathematics need to be informed about the course work that technology majors take. The resultant ability of the teacher to make instructional references to real world, technology problems can help make science and mathematics courses come alive, not only for technology students, but for all students.

Requirements need to be increased for science and mathematics course work, moving away from the apparent minimal standards that now prevail. The Undergraduate Studies Committee (1989) of the Council on Technology Teacher Education recommended that a minimum of 12 semester hours in science be completed by prospective technology teachers. As noted earlier, less than one fourth of recent graduates are meeting this standard. This committee also recommended that nine hours in mathematics and computer science be completed. Again, as noted earlier, an average of 7.6 credits were taken.

Fitting these courses into an already burgeoning curriculum is a challenge. The real challenge, however, may not be how to squeeze in the credits, but how to assure the quality of instruction. Often these courses are taught to very large classes of students and may not have a laboratory component. The instruction itself may be of low quality, with the courses often defaulting to inexperienced graduate students or mediocre professors. When this happens, it is not very conducive to motivating and exciting technology students about integrating mathematics and science into the technology courses they take, or to doing so once they begin their teaching careers. Despite these too-often-occurring realities, the need for technology teachers to have a solid background in science and mathematics is still essential for the future.

Professional methods courses should model what is expected of teachers in real school settings. Teams of technology, science, and mathematics majors should have the experience of planning and delivering lessons together. Even if the concerns about quality in science and mathematics instruction mentioned above cannot be resolved, such a cooperative experience is essential and may provide a salve for the wounds of the aspiring technology teacher who had a less than ideal experience with science and mathematics to that point. Finally, the integrated, team approach should extend to the student teaching experience, paralleling how team planning and implementation is supposed to work.

Perhaps it is time to consider a teacher preparation program that prepares an "integrated teacher"—a teacher who can take a group of students for an extended block of time and teach a course that truly integrates the three disciplines. In other words, prepare the prospective teacher from the outset as an integrator of the three disciplines. This would lead to teaching an integrated program simply because the instructor would not know any other way. No doubt there would be some serious tradeoffs and compromises, but it seems at least worthy of a feasibility study.

THE RESEARCH CHALLENGE

Research from a range of sources, many cited earlier in this chapter, suggests that further exploration of the notion of content integration is warranted. Notable among the research from the science and mathematics communities is the work of several individuals whose conclusions are in *direct* support of the idea of integrating technology education curricula with science and mathematics. Hamm (1992) identified a series of steps that should be taken to further the cause of science and mathematics education. These recommended steps cry out for a technology education laboratory in which to implement her vision:

1. Improve the teaching of science, mathematics, and technology . . . [by] providing students with active hands-on experience, placing emphasis on students' curiosity and creativity, and frequently using a student team approach to learning (Adams & Hamm, 1990).
2. Attend to the importance of students in the learning process. Students need to be placed in situations where they develop and create their own science understandings, connect concepts with personal meanings, and put ideas together for themselves.
3. Incorporate innovative and alternative teaching and learning strategies. Classrooms should be organized so that small mixed-ability

groups are a forum for mathematics/science discussions, discovery, creativity, and connections to other subjects.

4. Develop new curriculum models. To achieve the goals of scientific literacy, the curricula must be changed to reduce the amount of material covered and emphasize a thematic approach. There is a need to focus on the connections among the various disciplines of science, mathematics, technology and build integrated understandings. (pp. 7–8)

W. M. Roth, a high school physics teacher, began to recognize the role that physical apparati could play in the learning of mathematics and science. He conducted case studies of his high school physics students. The activities he describes are similar to those developed as technology, science, mathematics integration activities:

> The photo gate, the cart, and the springs which the students used in their experiment were part of the setting they controlled and which, in this sense, was like the real world. They recorded data, made charts, used MathCAD, submitted a report. . . . As Michael described the motion of the cart, he made connections between several levels of conceptual abstraction. . . . Finally, the apparatus used, a relatively easily observed physical system which can be replayed in slow motion, played a major role for Michael's construction of physics and mathematics knowledge. (1993, p. 115)

Roth's research led him to suggest the need for substantial additional research in this area. One such conclusion indicates the need for an entire program of research on the viability of teaching scientific and mathematical principles using concrete apparati as the stimuli. Research of this nature would help to reinforce or refute the pedagogical approach underlying the integration of technology education with science and mathematics in our schools:

> The implications for research are clear. First, a number of concrete apparati should be identified which have to satisfy two conditions. These apparati should lend themselves to anchor sound curricular units for the integration of science and mathematics, and they should be of a complexity which facilitates the construction of meaning rather than stifling it. Then, research should be conducted to investigate the construction of meaning in classroom settings in which science and mathematics teaching and learning is systematically organized around these apparati. Finally, research should be conducted to determine if

> and how such apparatus-centered curricula help establish classroom communities of meaning makers. (1993, p. 121)

Roth's conclusions help build a rationale for the sort of science and mathematics problems that are routinely encountered in technological problem-solving activities. He implies that the technological problem-solving activities that have customarily been used in technology education for the past decade are a perfect metaphor for the study of science and mathematics principles. These technological problem-solving activities, however, take Roth's notion to another level, since they allow students to design, construct, and evaluate their own "apparati" rather than those supplied somewhat artificially by the teacher. As Roth states:

> The results of this and other studies (e.g., Greeno, 1988) make it quite clear that students' interactions with physical apparati and events allow students to construct multiple representations and serve as anchors of both for conceptual science and mathematics knowledge. These apparati can be of a simple nature as Greeno's (1988) pulley crank system to study linear functions or a balance beam to study ratios. (1993, p. 121)

The idea of integrating technology, science, and mathematics curricula makes sense from a variety of perspectives. There is growing support from all three school disciplines involved. Moreover, the nature of learning promoted by this approach is beautifully aligned with the Piagetian, inquiry based, and constructivist learning theories currently under investigation throughout the educational arena. As with other movements in education, however, it would be misleading to suggest that all current efforts are solidly founded in empirical research. There is much work yet to be done in this regard.

CONCLUSION

More than at any time before in the history of education, the stage is now set for a closer working relationship among technology, science, and mathematics. A number of reports from very credible and politically influential sources have recognized the existence of technology and its vital importance in the education of America's citizenry. Funding opportunities are becoming increasingly available to support collaboration among the three disciplines. The concept of teaming among teachers of various subjects is being promoted and implemented in the schools, especially at the middle school level. Though insufficient at the present time, research evidence is mounting to show that technology education, with its hands-on, practical problem-solving approach, can increase students' interest in science and mathematics and can likely increase their understanding as well.

Changes are needed in the structure of schools if integration is to be realized. Technology teachers must be included on the same planning team as are the science and mathematics teachers. Ideally, the school schedule should be overhauled to facilitate integration. At the pre-service level, technology teachers must have a solid, quality experience in science and mathematics—one that stimulates the prospective teacher and exemplifies the value and importance of these disciplines. Prospective science and mathematics teachers, likewise, need a quality experience with hands-on technology education.

Beyond the benefits of learning in an integrative manner, there are clear benefits that integration with math and science would provide technology education. Most important is the potential to establish technology education as an essential educational experience for everyone. In this way it would attain the general education goal to which the field has aspired since its inception.

There are also potential threats, as well as benefits associated with integration. Perhaps most significant is the possibility that technology will remain educationally important, but that its instruction will be delivered by the math and science teachers. Though this scenario is possible, there are at least three arguments against it. First, the science and mathematics curricula are operating in a deficit, already, in terms of the instructional time needed to cover the prescribed content. Time and flexibility are major contributions that the technology curriculum can make. Second, the technology laboratory is a facility unlike any other in the school, specifically designed to teach technology. The equipment and materials in the technology lab enable the students to solve real, technological problems with real tools—not simply the cognitive problems in the textbook or those solved with cardboard, balsa wood, razor knives, and glue. Students realize an experience they may never again have in their entire lives. Finally, the technology teacher has unique, specialized qualifications to make this happen. The content and method that technology teachers bring to their classes are very rich and adaptable to an integrated approach to instruction. The ability to supervise many different problem-solving activities concurrently in a technology lab is a talent that should not be underestimated, and most math and science teachers have had little or no experience with this approach.

It is possible to conceive of a technology education program that could be delivered without the tools, materials, and expertise currently used by technology teachers. Such a curriculum might be taught by science or even social studies teachers. This, however, could never begin to provide the rich learning opportunities that are afforded by the environment created in exemplary technology education labs as we know them today.

Though one could argue that discipline integration and the teaming of teachers is but another wave of educational rhetoric that will wash the shore, the pervasiveness of interdisciplinary instruction in actual practice, particularly at the middle school level, causes even the staunchest pessimist to give this approach a second look. While there are numerous logistic barriers that may be used as an excuse not to integrate these three disciplines, surely students would benefit from seeing the content of each in this larger, real world context.

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CHAPTER 6

Technology Education Facilities

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Advances in technology are continuing to pose new challenges for all levels of education, with significant impacts being felt by many individuals, professions, and societies. The education sector has witnessed major changes in the past and these changes will continue to occur at an ever increasing rate as we move rapidly into the 21st century. These changes are particularly true for the field of technology education.

Technology education is unlike most other academic areas where standard classrooms and basic resources are often adequate to provide a meaningful education for students. The nature of providing hands-on experiences in the use of tools, materials, and processes used in a modern technological society, and the impacts that technological decisions have on the environment and society, require that technology education make wise use of a wide variety of equipment, resources, and problem-solving methods. This diversity can take the expanding role of technology into new and exciting frontiers. The technology education laboratory must provide an environment where the theory of the classroom is combined with the reality of accomplishing meaningful tasks through well organized instruction. Technology education would be little more than many of the typical classroom bound subject matter areas taught in the schools if it were not for the laboratory equipment that is so prevalent in the program.

The preparation of people for the future has always been a major goal of all aspects of education, and technology education is certainly no exception. It is critical that people in a wide range of careers and professions achieve a greater level of understanding of the technological world in which they live. It becomes less likely that they will be able to function effectively in tomorrow's society without this understanding. It is also less likely that our democratic society will be able to prosper and grow to its fullest potential if the individuals in our society do not have a basic comprehension of technology. This comprehension will enable them to make informed decisions about complex local, regional, national, and global problems. In 1820, Thomas Jefferson articulately voiced this concern in a letter written to William Charles Jarvis. He wrote the following:

> I know no safe depository of the ultimate powers of this society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform them of their discretion.

More recently, Boyer (1983), in a report funded by the Carnegie Foundation for the Advancement of Teaching entitled *High School: A Report on Secondary Education in America*, stated the following:

> We must 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. . . . We are frankly disappointed that none of the schools we visited required the study of technology. More disturbing still is the current inclination to equate technology with computers. . . . 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. The challenge is not to use the latest piece of hardware, but asking when and why it should be used. (p. 304)

All too often the general public gains its understanding (regretfully) of public education by simply looking at the facilities while not taking into consideration that facilities represent only the end product of the total educational planning process. Educational planners make facility decisions only after the curriculum has been developed. This chapter examines the role played by technology education facilities as one part of the total educational process, with particular focus on the planning and organizing of these facilities. This chapter also presents a review of the recent growth and development of technology laboratories and provides comparisons relative to the effectiveness of the new directions in laboratory design. Finally, the future direction of the technology laboratory design is examined.

THE ROLE OF LABORATORY FACILITIES

Purpose

It is generally agreed that the role of technology education within the school system is to promote technological literacy. In addition, learning theories commonly call for students to be involved actively in their own education. There is an inherent need, therefore, to provide educational space where this learning can best take place. This planned educational space is called the laboratory and, with respect to technology education, it is called the technology laboratory. The primary purpose of the technology education laboratory, therefore, is to support the approved academic curriculum.

The modern learning laboratory for technology education is far different from the traditional industrial arts facility of past years. In the industrial arts laboratory, the structure of the facility was material based. The student was expected to repeat what the instructor directed, thus demonstrating the development of some identified level of technical skill while building a variety of projects. The design of the modern technology laboratory no longer resembles the design for this traditional lock-step type of instruction. The purpose of today's technology laboratory is to allow students to explore, discover, and develop a variety of concepts on a nearly infinite scale. Today's students should leave the laboratory with a conceptual understanding of the clusters of communication, construction, manufacturing, and transportation. In each of these clusters, students should be able to describe and demonstrate a variety of processes and techniques common to the technological world in which they live.

The technology education curriculum would be greatly curtailed without the laboratory environment to promote the conversion of short term memory into long term understanding. The technology laboratory provides students with the opportunity to experience and thereby better understand, for example, such dynamics as (a) the directional strength of different materials; (b) the relationship among resistance, current, and voltage in an electrical circuit; (c) the importance of a variety of transportation systems; and (d) the concept of interchangeability of parts. Students cannot become literate in technology without acquiring these and a multitude of other technological concepts. It is only through meaningful laboratory experiences that students will be able to develop a comprehensive understanding of them.

Objectives

The role of the technology education facility is to provide the learner with the finest possible technological learning environment. The facility must be designed so that it will be able to meet this goal in an economical manner for an extended period of years. More specifically, the following considerations should be taken into account in the design of a technology education facility that will provide the best learning environment for the student, the community, the state, the region, and the nation. These considerations include the physical learning environment, design and layout, accommodation of the instructor, changing role of the school, and philosophy of facility design and development.

The Physical Learning Environment. The physical space must be attractive to both the students and the instructors. Current research in a variety of disciplines suggests a strong positive correlation between attractive learning environments and the rate and retention of learning. Laboratories designed for the future will also need to be easily adaptable and flexible, in order to meet the requirements of technologies that have not yet been envisioned. School facilities are typically designed and built with a life expectancy of 30 to 50 years. The common technology available for instruction in the year 2020 will be far different than it is today. Design flexibility, therefore, is critical so that the need for adaptations and changes to the facility can be accommodated from one year to the next. It is likely that extensive changes may not be so readily made and, consequently, state-of-the-art technology education will not be provided to the student without this design flexibility.

Inter- and intra-discipline connections will have a major impact on the acceptance of technology education into the mainstream of all of education. No longer should the technology laboratory facilities be relegated to wings of the overall school design and, therefore, be away from the core of the academic school. Technology education laboratory facilities should be centrally located so their resources and rich educational methodologies can be integrated into all school subjects. Careful planning must be undertaken so that the curriculum organizers within technology education are not isolated from one another. Students need to become aware of the relationships among the various components of technology and, in turn, have an understanding of the importance of technology within all other disciplines of the total educational program.

The work stations of modern businesses and industries are far different today than they were in the past and will continue to be redefined in the future. If one of education's major purposes is to prepare students for successful careers, then the instructional areas in the school must provide students with the opportunity to experience realistic work environments. In the workplace of today and tomorrow, greater emphasis will be placed on knowledge-based skills and less focus will be placed on simple, repetitive, mechanical tasks. These new and emerging requirements will dictate an alternative instructional strategy and, consequently, a learning environment quite different from traditional classrooms and laboratories.

Research findings on learning styles, as well as the exponential growth of technology, suggest that instructional strategies must be adjusted to meet the needs of current and future learners. The most recent trend is leading away from teacher-centered instruction and moving toward learner-centered instruction. This latter learning style requires students to accept a greater responsibility for their own learning under the guidance of the instructor. The instructor will work more as a facilitator of instruction and less as the sole resource and provider of information and direction. The technology education facility for learner-directed instruction will be dramatically different from that of a traditional classroom and laboratory of the past.

Current and future new directions for education will require that the technology laboratory be equipped to provide learners with the necessary materials, tools, equipment, and processing items that will give them the greatest opportunity to explore and develop understandings in a wide variety of areas. The physical configuration of the laboratory will have to be designed in such a way that learners will find the facility easy to use, with a minimum of artificial constraints placed in their path, for developing an understanding of the specific topic under study. Technology education will also require students to be involved actively in their own learning. This means that they may well be generating chips, smoke, sawdust, and sparks in addition to interfacing with computers and videos, participating in interactive instruction, and experiencing other learning methods and techniques. The laboratory must be designed to accommodate the various types of instructional activities in a safe and efficient manner.

Problem solving is the wave of the future in all the academic disciplines. Technology education has, for the past several years, been very active in promoting individual and group problem solving as a method of allowing students to develop higher order thinking skills and, at the same time, providing the motivation to make education "come to life." Laboratory space is needed to accommodate this type of learning activity. Smaller, quiet areas as well as larger, more active areas should be incorporated into the early design phase of any remodeling or new construction that is considered for the technology education facility.

Naturally, a common objective of any technology laboratory is that the space be barrier free for students with handicaps. When handicap access is properly planned, few additional expenditures will be necessary when the time comes for the facilities to be upgraded. They must also provide equally for both females and males. This requirement seems almost second nature in today's social environment. As recently as 20 years ago, however, facilities were designed for only one sex, with little or no regard for the individual who wanted to explore technological areas that were nontraditional to a particular gender.

Accommodation of the Instructor. The ease with which the teacher can function in the laboratory is another factor to be considered in planning for future technology facilities. The teaching, management, and controlling functions of instruction need to be planned carefully if the total facility is going to operate at maximum efficiency in the future. The designer must consider the teaching role and how the physical layout of the space will impact the teacher as well as the learner, while keeping in mind the new styles of learning. Another consideration is the impact of the rapidly advancing instructional technology on the role of the teacher as well as the learner. The facility must be designed with all parties in mind to maximize the efficient use of the total school facility.

The Changing Role of the School. In the past, the school was designed for and used by the traditional school-age student. This focus has been greatly expanded today as the public has become more cognizant that tax dollars are not being used as efficiently as they might be when school facilities are used only during part of the day and only for nine months of the year. The technology education laboratory in particular is one that will have considerable appeal for providing instruction in the advancing technologies to individuals beyond the traditional-age student. Classes for these citizens are typically held during times that regular school classes are not in session. Adult evening classes, weekend classes, and summer sessions are realistic possibilities that are currently being considered in many parts of the country, particularly as citizens see their taxes continuing to rise to support education. Technology education planners today, more than ever before, need to take into consideration the extended use of facilities as they design and remodel these environments for the future.

Philosophy of Facility Design and Development. Although the philosophy concerning the type of laboratory that should bring technological literacy into fruition has not been agreed upon by the profession, several generally accepted principles are beginning to emerge. It is generally agreed that the laboratory is a critical component of all technology education programs. In the elementary school, the laboratory is often the classroom itself with a selection of activities based on the age of the students and space availability. Still, the goal remains the same—to provide students with concrete learning experiences in which they manipulate tools and materials to produce solutions to real problems.

The typical middle and junior high school programs require the development of a separate space where specialized tools and equipment can be used without disrupting other students. Unlike the traditional shop of past years, where the major concentration was on drafting and woodworking, the modern facility should encompass the four cluster areas of communication, construction, manufacturing, and transportation. It must have a variety of tools and equipment available for use in each cluster, as well as within and among all the others. No longer is it adequate nor does it serve the best interests of the students to limit them to a single material or process.

At the high school level, the laboratory may be divided into the four clusters. In larger school systems, a laboratory for each of the clusters with a common space between the laboratories is often part of the design, so collaborative work can be conducted. This common area also provides a space where interdisciplinary work and study can take place. Just as the walls between disciplines have become less defined, so must the distance between academic subjects and the applied areas become less pronounced.

The technology education program at the teacher preparation level must incorporate all of the techniques previously described for the elementary through secondary levels. The students must be able to gain experience in a wide variety of laboratory designs and functions. To be effective in the early years of their technology teaching careers, college students must have the opportunity to design curriculum and learning activities in a laboratory that can be set up to duplicate those that they may find in the public schools.

Types of Laboratories

Although a new format for education in the technologies is developing for the 21st century, it is often constrained by the presence of obsolete 19th century buildings. School administrators and architects have been charged with the responsibility to design facilities that will promote and enhance a sound educational philosophy and exemplary curricula. During this critical transition time from the old curriculum emphasis on industrial arts to the new curriculum thrust of technology education, problems arise when individuals are asked to provide input for the design of new technology education facilities. Through no fault of their own, many school administrators and architects have difficulty identifying and understanding the changes that have taken place in the technology education field over the past 10 to 15 years. Generally, the major portion of their own formal education was completed during the time that industrial arts was prominent and curriculum changes advancing the movement of technology education were only beginning to take place. Consequently, these individuals possess little knowledge or understanding about the types of facilities that are needed to support the contemporary technology education curriculum. It is the shared role of the classroom teacher, state supervisor of technology education, technology teacher education faculty, and professional associations to provide the necessary information and materials to school designers and community leaders so they may better comprehend the need for up-to-date technology education facilities.

Historically, there have been three major types of secondary and higher education facilities. These were the unit shop, where a single type of activity, such as machining, was taught; the general unit shop, where instruction about the use and fabrication of a single material, such as metals, was taught; and the comprehensive general shop, where various materials were incorporated into the instructional program. Along with the major shop (laboratory) areas, there were many auxiliary areas, such as instructional resource sections, seminar rooms, storage and finishing rooms, and teachers' offices. Laboratory size varied with the types and quantity of equipment to be utilized and also with anticipated future enrollments. Historically, the geographical location of the entire industrial arts facility was isolated from the other academic areas of the school. The program was considered to be an elective area that generated considerable noise and dust. The industrial arts facility was also considered to be an instructional area for those students who were not interested in pursuing or did not have the ability to continue their education at the college level. Sadly, this "dumping ground" mentality is still prevalent in many schools and is being perpetuated by school administrators and the community at large.

There are many individuals and school officials, however, who recognize the need for all students to develop their technological competencies. These same people often lack the background and knowledge to design a program that will provide students with the needed skills to compete in a global economy. The term *technology* is often a catchword that excites the public. Unfortunately, the term has many different meanings when it is combined with other words, whether those other words precede or follow the word technology. For example, *educational technology* is very different from *technology education*. Although both are important in the educational setting, they require different types of laboratories and instructional strategies. This confusion in semantics can either enhance or hinder the progress of technology education. In addition, faculty in the traditional disciplines, such as physics and chemistry, are beginning to adjust their curricula to include the application of technology to teach their respective disciplines better. All of these activities are contributing to the confusion in education regarding what type of facility should be designed and built. It becomes the task of the local technology education teacher to provide necessary information and insight to people interested in the school system, so that these individuals can better understand the facility needs of technology education, as well as the important role this discipline has to play in developing the technological literacy of students.

FACILITY PLANNING AND ORGANIZATION

The design and construction of school facilities is a very complicated process that cannot be covered adequately in a few pages of a single chapter and, perhaps, not even in a single book. It involves a host of concepts, the contributions of many individuals from a variety of professions and, in the end, the entire process must be supported by taxpayers. It is very important, therefore, to plan carefully and to involve all interested parties in the process from the beginning, so that everyone has an understanding of and is in agreement with the direction that should be taken with the new technology education facility. Although the entire process is quite complicated, time consuming, and dependent on a great deal of study, a beginning point is an understanding of the basic principles of technology education facility design.

Basic Underlying Principles

The basic principles of the technology education facility design are those that will remain relatively stable through time. Even while the technology education curriculum continues to change as technology changes, there will always be the need for a solid foundation upon which to base decisions. Without this sound foundation to assist the participants in reaching a consensus, continuing efforts will be unfocused and without direction.

The educational philosophy and the mission statement of the school system must be completely understood before a philosophy statement for the technology education program can be put into practice. There is little use in attempting to move forward in the restructuring of the technology education curriculum, let alone in developing the facilities to support that curriculum, without strong mutual support of the statements.

The Curriculum Plan. In order to prepare technologically literate individuals through technology education, a curriculum that supports the school's philosophy must be put into place. As with any curriculum development process, there is a need to identify the purpose of the curriculum, the resources, and the societal needs, and then to outline the instructional content that will meet these needs. The curriculum plan is not something that can be completed in a few hours or even a few days or weeks. The instructor can no longer design the curriculum one year and expect it to be permanently relevant. Instead, it should be an ongoing document that is reviewed often and is continually undergoing change.

With a curriculum design well in place, one can order new equipment or remodel or update facilities without the real danger of spending difficult-to-obtain dollars in a wasteful manner. It cannot be overemphasized that before any piece of instructional equipment or resource is purchased, it must first meet the criteria for enhancing and supporting the stated curriculum of the program. The American public will no longer tolerate unwisely spent dollars.

Analyzing and Evaluating Current and Future Needs. Once the technology education curriculum is well established, the instructor can begin to analyze what laboratory space, equipment, and resources are in place and assess what additions or changes are needed. It is human nature to collect things we believe we may use in the future. Unfortunately, by the time the future arrives, the items that have been collected are often obsolete and of little value. Based on specific lessons identified by using the curriculum, needed tools, materials, equipment, space, and time should be allocated to assure that students are provided with the physical environment in which to achieve the desired outcomes. A listing of items needed for each lesson will provide the requirements for the technology education laboratory. This list should then be compared with available physical facilities to determine what additions may be needed to support the curriculum. At this point, reality may dictate compromises, as some of the proposed items may be well beyond the scope of the program or resources of the school at the immediate time. This situation can provide the motivation for the development of grant proposals to organizations and to public and private foundations for the acquisition of needed items.

Renovate, Remodel, or Build? At some point, a decision must be made to renovate and remodel an older facility or to build a new one. There is a very real need to analyze all options carefully before making any final decisions, because construction activities are very costly, of long duration, and must be financially supported by the public. Often there will be considerable public pressure, but the final decision must be dictated by how the facility will enhance the education of those who will be educated within it. In some cases, simply remodeling will meet the educational needs of the community. If, for a variety of reasons, remodeling will not meet these needs, then new construction should be seriously considered. In either case, the process is not a simple one and will require a great deal of commitment and work on the part of school officials, as well as the community.

Personnel Involved

If one of education's major goals is to develop a technologically literate citizenry, then it behooves the decision makers to include as many individuals as possible in the planning of any major remodeling or new construction for technology education. The implementation of a plan that will involve the participation of a great number of individuals must be carefully thought out so that effective communication among all of the planners can be maintained. The initiation of any sizable facility change should begin with the faculty of the program. The faculty must determine the match between the technology education curriculum and the school board's educational philosophy and goals for the school. Once this assessment has been completed, the current facilities can be evaluated and measured against these policies to see if there is a need for facility changes. The school administration must be kept constantly apprised of all the activities throughout the process.

The chief school administrator (usually the principal or superintendent) must consider a variety of school-related issues and therefore must be well informed concerning any extensive remodeling or new construction. The school administrator then carries any substantial requests for new dollars to the school board for its reaction and approval. There is little chance of success in receiving funding to renew a facility without the support and the ultimate approval of the board. If approval is given, then the general public is made aware of the plans. At this time, the board, in consultation with the school administrator, may employ a design team consisting of an architect, an engineer, and a school planner to visit with the teachers and administration for the purpose of making a preliminary proposal either for remodeling or for new construction. Once the preliminary figures are assembled, more concrete decisions can be made and a sense of the public's support can be assessed. Assuming a favorable outcome, the work begins by school officials to convince the taxpayers that the investment in the facility is in the best interest of the community and should be given due consideration. The design team begins to put together the final plans so that an advertisement for bids may be conducted, bids received, and a bond issue advertised and voted upon by the public.

As can be seen from the previous discussion, there are many individuals involved in the initial and intermediate planning stages. At a later point in the process, other persons may actively participate when the issue of the public building is placed before the voters. Many steps are involved before the project can be brought to successful fruition. The teachers and the school administration shoulder the responsibility to move an idea forward for public approval to complete the construction. In addition, there are a number of building codes and plan checks that must be completed and adhered to before the project can receive final approval from state agencies. It cannot be overemphasized, therefore, that the entire process will take careful and coordinated planning by all personnel involved.

Educational Policies, Beliefs, and Laboratory Requirements

The last 20 years have witnessed the most rapid and extensive changes in technology since the beginning of our industrial society. All indications are that these changes will occur even more quickly in the future. In periods of rapid change, the lag time caused by traditional policies, practices, and beliefs is increased by individuals and agencies who are out of touch with current developments. Some people believe that schools that were good enough for their grandparents are good enough for their children. In recent years, however, many individuals have come to the realization that we have made the transition from a production society to an information society and that knowledge-based instruction is moving to the forefront. The traditional values held by people who were educated in the industrial arts era are giving way to an acceptance that technological literacy is required of all students if they are to be competitive in the technological global workplace of the future. The relationship between traditional programs and the needs of the 21st century provides the profession with a challenge for designing facilities that will meet these needs.

The process of change and modernization has been ongoing for at least a decade, with the most rapid changes occurring more recently. We are seeing more of our teachers selling off traditional equipment and replacing it with computers, information systems, and sophisticated material processing tools and, in general, updating their facilities. As technology education teachers become more accustomed to this type of equipment, the school administration, other teachers in the school, students, and parents will accept this approach to assisting students in becoming technologically literate.

Some administrators, school designers, and teachers still remain confused by all the changes that have taken place in technology education. A review

CONTRASTS BETWEEN LABORATORY TYPES

Industrial Arts (IA) Labs	Technology Education (TE) Labs
Goal: To develop technical skills based on the factory era system	**Goal:** To develop broad-based concepts based on technological literacy of the information age
Curriculum: Materials based	**Curriculum:** Systems based
Lab Design: Teacher centered with instructor as the major source of information	**Lab Design:** Student centered with teacher as the facilitator of learning; self-directed, modular based
Lab Space: Large and primarily limited to a single material or activity	**Lab Space:** Flexible and adaptable to a variety of instructional activities
Lab Location: Separated from main core of the school	**Lab Location:** Centrally located to assist in the integration of all disciplines
Lab Equipment: Large, semi-industrial, with considerable duplication	**Lab Equipment:** Smaller, high quality, with little duplication

Figure 6-1: A comparison between industrial arts and technology education laboratories.

of the literature on school planning reveals that the terms *industrial arts* and *shop* are still used today to describe technology education. A major effort must be undertaken to inform people that a change has taken place from the goal of teaching skill specific tasks using a few basic materials to one of promoting an understanding of concepts and systems in the areas of communication, construction, manufacturing, and transportation. Today's facilities are far different from those of past years, when simple materials processing equipment was needed in individual laboratories. When the public is made aware of these changes and the types of activities in which students are currently involved, support is generally strong and enthusiastic. Today's direction is away from the traditional shop program to a conceptual program, from the factory-based era to the information era, from the teacher's role as the provider of all knowledge to the role of a facilitator, diagnostician, collaborator, and guide who encourages students to be self-learners. Figure 6–1 provides a comparison of the two types of programs.

GROWTH AND DEVELOPMENT DURING THE 1980s AND 1990s

Curriculum Influences

The laboratory is the support structure for the curriculum of the technology education program. As the curriculum adjusts to the needs of society, the laboratory must also adjust to match those changes. Historically, this can be seen through the changes in the various movements the profession has experienced. The movements have passed from manual training, where students were taught manual skills based on specific exercises, to technology education, where the laboratory is set up to provide students with the opportunity to develop concepts in broad cluster areas.

During the 1980s, the primary movement towards a technology education laboratory began with the Jackson's Mill Industrial Arts Curriculum Theory project (Hales & Snyder, 1981). (A more complete description of this project is found in Chapter 7 of this yearbook.) This curriculum effort established the foundation for the change from teaching just basic technical skills in the laboratory to developing broad based conceptual understandings in the areas of communication, construction, manufacturing, and transportation. The acceptance of this curriculum theory by leaders in the profession began the gradual shift in laboratory design to meet the goals of the new curriculum better. Another significant development during the past decade was changing the name of the professional association from the American

Industrial Arts Association (AIAA) to the International Technology Education Association (ITEA), which gave further impetus to the evolution of the modern technology education laboratory. (A more complete description of the ITEA is found in Chapter 17 of this yearbook.) In order to adjust the laboratory to the new approach of technology education, teachers in the field began to package instructional materials into small, discrete units. With the beginning of simple technology learning activities (TLAs), which allowed teachers to add new material into their classes while still maintaining their traditional offerings, the instructors were able to try out this new area of technology education without completely letting go of their traditional programs. With the further development of the TLA into a learning module, the laboratory began to take on a new look, with various sections and areas of the laboratory containing space set aside for the modular based activities.

On the negative side, however, many instructors simply added the word technology to their traditional woodworking, drafting, and metalworking classes while making few or no changes in their curriculum or laboratory (with the exception of adding a few pieces of expensive, high tech equipment). This was unfortunate in that such programs served to confuse the student and the public, while offering only specialized technical skills that had little meaning beyond the specific area under study.

During the latter part of the 1980s, many state associations changed their names to include technology and developed a number of state curriculum guides that provided teachers with the philosophical background and curriculum organizers for technology education. During this same time frame, textbook publishers began to make available to the profession a variety of technology textbooks as they started to move away from the traditional woodworking, metalworking, and drafting texts. These influences helped to change the traditional shop areas into contemporary technology laboratories. In the past 10 years, the curriculum changes that have impacted the design of the technology education laboratory have been affected by a number of professional monographs and publications such as *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990), *Technology: A National Imperative* (Technology Education Advisory Council, 1988), and *Technology Education: A Perspective on Implementation* (American Industrial Arts Association, 1985).

In very recent years, the acceptance of technology as a curriculum organizer, and therefore an influence on the technology laboratory, has been enhanced by state, federal, and private funding agencies. The National Science Foundation in particular has made its funding more available to technology educators who are interested in demonstrating the connection among technology, mathematics, and science education. The Technical Foundation of America has provided funding for a significant number of curriculum development and professional activities that have assisted in the further development of technology education. Many states have provided funds for curriculum development to assist in the change toward technology education. The entire effort of external funding for technology education has precipitated a variety of funded projects at the local, state, and national levels. These projects are intended to demonstrate a hands-on, practical approach provided by the technology laboratory to develop a better understanding of and connection among all disciplines.

Technology Influences

Perhaps the single greatest technological influence the laboratory has experienced in recent years is the widespread availability and use of personal computers. Today's laboratory is totally out of date if it does not contain several computers that allow the student to perform word processing, control machines, organize data, generate graphics and drawings, participate in a telecommunications network, simulate systems, etc. To some extent, the importance of the computer has overshadowed other technological developments such as lasers, fiber optics, computerized numerical control (CNC), interactive instruction, camcorders, and VCRs, all of which are equally important. The rapid advancement of technology and the design and changes in the technology laboratory will continue at an ever increasing rate and will require that the student be technologically literate in a wide variety of emerging technologies. The time frame for technological changes to move from the developmental stage to the manufacture of consumer products is becoming shorter and shorter. Care and thoroughness in selection should be exercised when purchasing new equipment, since newer and more powerful hardware is constantly being introduced into the marketplace by various vendors at competitive prices.

Teaching Influences

The educational process has undergone major changes in the last several decades. Recent research indicates that students learn through a variety of learning styles. It is the instructor's task to adjust teaching styles to best match those of the learner. To accomplish this task, a variety of delivery methods and approaches need to be designed so the student will have the greatest opportunity for success. Of course, each teaching style requires a slightly different classroom and laboratory arrangement. At times it may be appropriate to present material to a large group of students using the traditional lecture mode, while at other times individual instruction is more appropriate. In still other situations, problem-solving models and simulation may work best. Each of these teaching and learning styles may require a different arrangement of equipment, supplies, and instructional media within the laboratory. The modern technology education laboratory should be able to adjust to these different teaching and learning styles for the most effective education to occur. With the advent of TLAs and modular instructional units, there is a need to be able to adjust the various instructional areas to meet the needs of the learner best. It is also more economical and feasible to change and update one or several modules in a given time period rather than to redesign the entire laboratory completely at one time. The TLAs and modules are relatively easy to update and adjust in keeping with the changes in technology and, consequently, are very appropriate to consider in the development and upgrading of any technology education laboratory.

PRESENT LABORATORY FACILITIES

Identification of Type of Laboratory Required

There are a variety of ways to incorporate the technology education curriculum into the laboratory depending on the educational level, the size of the school, or the arrangement of the total school curriculum. At the elementary level, the technology education laboratory generally is incorporated into the existing elementary classroom according to the availability of common tools and additional storage and work space. Technology education activities at the elementary level should be used to reduce the abstraction of the area under study and to enhance the students' technological literacy and understanding of the importance of technology in today's society. Young students can best learn about technology if it is integrated into all their lessons. The facilities to accomplish these tasks do not have to be expensive or extensive. Often, small tool carts in the classroom will provide the needed equipment for the limited strength of the small hands of children who have minimal eye-hand coordination. Teachers should select materials such as soft woods, plastic, paper, cardboard, plaster of Paris, and so forth, which will be easy to process with simple tools. Activities should not require close tolerances or fine detail. Instructional resources should also be on hand in the classroom and be available to the students through magazine racks, bookshelves, and bulletin boards.

At the middle/junior high school level, there is a definite need to have a separate technology education laboratory. The exploratory nature of the curriculum at this academic level dictates that broad-based technology laboratories are the most appropriate type of facility. Depending on school size, one or more laboratories may be needed. The typical laboratory in a small school would allow the student to explore a variety of technologies in each of the four clusters of communication, construction, manufacturing, and transportation. The facility should be flexible in nature so as to promote the integration of other subject matter areas, as well as to enhance the student's understanding of technology and its place in modern society. If the facility is going to be part of a new building, serious consideration should be given to locating the technology laboratory in close proximity to the central part of the school building and next to or incorporated with other resource centers, such as the library or media center.

Technology laboratories in a large, comprehensive senior high school are appropriately set up for each of the systems of communication, construction, manufacturing, and transportation. In this arrangement, students can elect to develop a comprehensive understanding of one of the four clusters. Depending on each individual's educational desires, the student can continue her/his education at an area technical school, a college or university, a community college, or through on-the-job training. Ideally, the laboratories should have the latest equipment in each of the clusters. A few examples of the activities that would be taking place in the facility include constructing, building, experimenting, discussing, researching, writing, simulating, role playing, and presenting. With this wide variety of activities taking place concurrently in the same laboratory, careful planning is required to assure the activities are compatible. Noisy and dusty operations will have to be isolated from activities requiring a clean environment. Individual learning units will need to be separated from large group discussions, and interactive learning will need to be isolated from presentations and discussions. All of this will require that the facility be flexible and easily adaptable to the changing needs of the students and the curriculum. Very few pieces of laboratory equipment should be permanently attached, so that they can be moved from place to place as the educational need arises.

The teacher education facility should be the most adaptable of all the facilities. Teachers in training will need to experience the entire variety of laboratory conditions and, in fact, should be able to go into an area and set up a demonstration laboratory for a particular school setting. They should also have available an extensive curriculum library and resources to assist them in designing and developing lessons in all areas of technology. As beginning teachers, these individuals will be expected to develop a full array of competencies, both technological and technical, and to go into the classroom and effectively assist their students in becoming technologically literate. Without having the opportunity for many types of experiences, however, new teachers will struggle for several years before they can effectively organize a laboratory to teach about technology.

Purposes and Influences of the Laboratory

The purpose of the technology education laboratory is to provide an environment where the student can study technology, develop competencies in a specific area, and become knowledgeable about how technology relates to the other academic subject matter areas offered in the school curriculum. Within the last few years, many individuals, professional associations, private industries, and foundations have embraced the idea that a better understanding of technology is critical for the long-term growth and prosperity of the nation. Without citizens who possess this understanding, the United States faces a major risk of losing its dominance in the global marketplace.

Technology means many things to different people. The technology education laboratory is one area where people can actually witness instruction in the technologies taking place. The influence of a well organized technology laboratory can go a long way in promoting the need for additional expansion in this area. Conversely, if the laboratory is outdated and still retains the project approach with single materials, the public may not support funding to update the facility. The influence the laboratory has on the students and the general public cannot be overstated. It is one of the few places where the public can easily observe what is occurring in the schools. If all that can be seen are well sanded and finished wood projects, then they will have a difficult time perceiving the facility as capable of providing a modern technology program, particularly when they can easily draw a comparison with the technological changes they are experiencing in their own workplaces.

Laboratory Functions

It is a function of the technology laboratory to promote a positive image that is representative of the quality of education being provided for the students enrolled in its classes. If the program is basically the same as it was 10, 20, or 30 years ago, then the program is not helping students to develop their technological literacy. It is doing little more than providing instruction in hobby types of interest. An additional function of the technology laboratory is to provide for the application of principles and concepts of other disciplines. Mathematics and science teachers are coming to grips with the need to reduce abstraction of their subjects. Technology education has the tools, materials, processes, and the laboratory space needed to provide a multitude of activities and experiences to assist other disciplines in this area.

Very recently (primarily during the 1990s), the profession has witnessed the acceptance of instructional modules as a means of providing instruction in a variety of technologies at an affordable price. Various design and manufacturing companies have refined the module concept so that excellent selections are now readily available for use in the laboratory. Many individual teachers have also developed their own modules with excellent results.

COMPARISON AND ANALYSIS

In the past it has been difficult for the casual observer to distinguish between a typical industrial arts facility and its vocational cousin, a trade and industrial education facility. For the most part, both programs used the same or very similar equipment and provided instruction in the same manner. The major difference was the amount of time the student spent in class. With the move away from industrial arts to technology education and the ensuing change in laboratory facilities, the differences have become more pronounced, with a definite shift toward general education by technology educators. The duplication of equipment such as saws, lathes, etc. are not part of the technology laboratory. Instead, there is a wide variety of equipment, not so much to teach technical skills, but to provide literacy in all of the technologies. With the accompanying change in the curriculum, school administrators and the public are becoming more aware of the need for this type of instruction for all students, just as they are aware that an understanding of mathematics, science, social science, and so forth is needed to become a well educated individual. The technology education laboratory is not just for the student who plans to enter the work force after graduation from high school, but for all students regardless of their backgrounds or career goals.

Teaching Effectiveness

Many traditional industrial arts teachers were reluctant to make the transition to technology education because of their educational background and training. Those who have made the switch, however, have become the very best supporters of their newfound role. Their enthusiasm for teaching has been renewed as they have become excited over learning new information about the latest technological developments. Technology education provides them with an infinite variety of challenges that renew their desire to continue to learn and to update their programs, so that their students can be on the forefront of technology. Their enthusiasm is contagious. Technology education teachers soon find their students are more excited than ever before, other teachers are interested in finding out about this new program, the administrators are providing additional dollars to assist in the development of the laboratory, and the parents and general public are wanting to take part in open houses and parents' night to discover why their children are suddenly more interested in their school work.

Learning Effectiveness

Student motivation is perhaps the greatest tangible result that can be identified with a quality technology education program and laboratory. Our students are bombarded by all kinds of technology each day. They are part of the instant world of communications, they have a basic idea about construction and the need for transportation, and they all are attuned to the latest manufactured clothing and goods. They are also cognizant of not wanting to work in a service job for the rest of their lives. Consequently, they are interested in developing a better understanding of the newest technology that will enhance their ability to use the latest innovations and inventions in their everyday lives. This is far different from the level of awareness 20 years ago when students (nearly always boys) were content to learn how to build projects from single materials. The enrollment in traditional project-building classes has declined considerably over the past several years, because the curriculum of the 1970s does not attract today's youth.

In the contemporary technology laboratory, the student can design a personal learning plan and pick from a number of instructional activities to arrive at a predetermined level of competency. The instructor is more of a facilitator and manager of learning. Students take on the responsibility of learning what is appropriate for their interests, abilities, and aptitudes. No longer are they relegated to lock-step instruction where all members of the class move forward at the pace of the average student.

FUTURE DIRECTIONS AND EXPECTATIONS

In the future, there will always be the need to provide students with the opportunity to study and become familiar with current technologies. The logical place for this study to occur is in a laboratory that is specifically designed and equipped with the latest technological materials, tools, and equipment. Whether this laboratory will be staffed by a technology teacher or by another school professional who is familiar with technology but has training in a different discipline remains to be determined. What is of utmost importance is that students have the opportunity to work and study in such a laboratory. With the gradual shift away from teacher-led activities, lock-step advancement through the grade levels, and orientation according to prescribed time frames, the technology laboratory will have to continue to change in the same direction that it is currently moving—that is, toward individualized instruction and multiple-use activities. The technology area, because of its application orientation, has a great opportunity to lead other disciplines in the restructuring of their teaching methodologies. In today's technology laboratories, we are already witnessing outstanding teachers changing their role to one of guiding the instruction of their students through expediting, managing, and motivating their students' learning plans. This style of instruction will have to be expanded during the next decade if we are to meet the needs and challenges required for a quality lifestyle in the 21st century.

Given the exponential growth of technology over the past decade, it is a near certainty that such a trend will continue. The challenge to the designer of technology laboratories is to provide the space and utility connections needed to be able to adapt to the changing technological innovations in the future. The public is able to support major new construction of school buildings only on a long-term basis. As we are faced with the rapid changes in technology, we will have to design into new laboratories a system whereby they can be remodeled and updated on a much shorter time schedule. This necessitates that the original structure be designed and constructed in such a way that future remodeling and updating will not be overly costly, either in time or in money. The successful technology laboratories of the future will be flexible and very adaptable to new technologies. This means moveable walls and utilities to accommodate not only changing technology, but also changing teaching methods.

In any community, there are other entities besides the school that must keep abreast of the latest technology in order to remain competitive and meet the needs of customers and clients. Business, industry, and a host of public and private agencies must all continually update their operations. Designers of the technology laboratory of the future should take the entire community into consideration during the early planning stages, so that collaborative efforts may be incorporated into the new program.

The public's demand for more value for its tax dollars will drive the need to utilize school facilities better by incorporating additional activities beyond the traditional scheduled program. Technology learning centers of the future will be designed to provide a laboratory instructor/manager who will coordinate the learning of a variety of technologies by a large array of customers. Some instructional modules may be semi-permanent, while others will be of limited duration and constantly changing. The laboratory will provide training for company employees, adults who are interested in learning new skills and concepts, and the school age student. All of these individuals will need to enhance their understanding of a rapidly changing technological world. The best and most efficient place to do this is in the well designed and operated technology laboratory.

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CHAPTER 7

Technology Education Curriculum Development Efforts

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Civilizations around the globe have experienced rapid and radical changes as they have moved along their journey from agrarian-based societies, to industrial-based societies, and on to information-based societies. Toffler (1980) characterized these transitions as waves of change. The first wave occurred when the hunter-gatherers developed agriculture and migrated to the great river valleys in what is now known as Africa and the Middle East. This wave stimulated a need for centralized government, engineering, new technologies, and different forms of education. Apprenticeship for the trades and narrow academic schooling for the elite became the accepted educational delivery system. Many present-day societies are still locked in this stage of their development (Toffler, 1970).

The second wave of change came to Europe and America with the Industrial Revolution of the 17th century. This wave stimulated the growth of cities, encouraged the development of large factories, caused a division of labor between workers and managers, and created many new demands on government, commerce, and education. A number of critics at that time viewed existing schooling as inappropriate for the new age. Public school curricula were based on the seven liberal arts of the Middle Ages: grammar, rhetoric, dialogue, mathematics, astronomy, music, and philosophy (Daley, 1966, p. 39). These traditional subjects failed to address the needs of an increasingly technically oriented society. Out of a call for educational reform in America came several new programs including manual training (circa 1880), followed by manual arts (circa 1895), and then industrial arts (circa 1904). These programs had their primary roots in a system of technical training that had been developed in Russia during the early 1800s and which emphasized tool skills and technical knowledge in the areas of mechanical drawing, woodworking, and metalworking.

The third wave of change is now upon the global community. It has been described as the information age, the computer age, the electronic era, or the post-industrial era. It is characterized by a rapidly increasing pace of change in which information and knowledge are being substituted for brute force (Toffler, 1990). Specific skills are being rapidly replaced by new ones. For example, the typesetter has been largely replaced by the word processor operator. Manual machine operators are being replaced by computer controllers. Machine malfunctions are being identified and analyzed by computers and often corrected by the machine itself. Manufacturing machines are changing their speeds and feeds as adaptive control systems monitor the performance of their cutters. Similarly, the technology of everyday life changes almost before our eyes. Cash registers are being replaced with bar code readers. Automobile engine performance is evaluated and malfunctions are diagnosed by computers. Homes are replete with digital controls.

Many people in the information age can identify with Burke (1979) who stated that if you understand a technological device, it is already obsolete. This condition of life requires flexible, adaptable people who have a different type of education. The information age requires people who can work together, understand its processes, and see education as a lifelong endeavor.

Feather (1989) similarly described societal transformation as waves of change but divided the civilization process into six waves that depict a human-driven movement from serfdom to global freedom. His last four waves are subsets of Toffler's third wave. Feather's waves of change are the following:

- 1st—Wave Society—up to 1880: agriculture
- 2nd—Wave Society—1880–1935: manufacturing
- 3rd—Wave Society—1935–1990: services
- 4th—Wave Society—1990–2045: information/knowledge
- 5th—Wave Society—2045–2100: leisure
- 6th—Wave Society—beyond 2100: outer space

Feather identified and described a number of factors in each of the six waves. Five of these factors and their relationship to the first four waves have particular interest to this discussion. They are shown in Figure 7–1. Feather's model suggests that for most of human history the vast majority of

	1st Wave Society	2nd Wave Society	3rd Wave Society	4th Wave Society
FOCUS	Agriculture	Manufacturing	Service	Info/Knowledge
TIME FRAME	Up to 1880	1880-1935	1935-1990	1990-2045
LIFE STYLE	Tribal Serfdom	Work Ethic	Lifestyle Ethic	Leisure Ethic
VALUES	Survival of the Fittest	Selfishness/Competition		Cooperation
EDUCATION	Illiteracy	Basic Literacy	Literacy/Education	Higher Education
EMPLOYMENT	Slave Labor	Secure Job (60-hr/week)	Meaningful Work (40-hr/week)	Stimulating Work (30-hr/week)

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Figure 7-1: Needs and Aspirations (From Feather F. G-Forces, p. 17).

people were engaged in growing the food and fiber needed to sustain life. In the United States over 90% of all people who worked outside the home were engaged in agriculture as late as the early 1800s.

The Industrial Revolution brought on a new way of living. Technology in the form of devices like the reaper and the moldboard plow helped mechanize the farms. These devices increased agriculture productivity and freed people to work in other pursuits. Many people moved from the farms into the developing cities to work in the factories that were beginning to emerge. These work places soon became characterized by mechanization, interchangeable parts, division of labor, and continuous production and assembly. A new class of worker, the manager, was born and so was the labor union.

In the early 20th century, the American society began moving from a manufacturing emphasis to a service focus. The growing population required both goods and services to support it. Transportation and communication technologies began playing a more important role in everyday life.

Today, America has moved into an information-knowledge age. This new age is viewed in either of two perspectives. One perspective is the "gloom and doom" view that suggests people are being controlled by technological change and they are helpless to alter the course of history. The other perspective is the "under every cloud is a silver lining" view that sees great opportunities ahead as humans address the pressing needs of the planet through technological advancements.

Naisbitt and Aburdene (1985) communicated an optimistic view of the future when they stated, "We are living in one of those rare times in history when two crucial elements for social change are present—new values and economic necessity" (p. 2). Likewise, they also indicated that society is in an age of new humanistic values that places emphasis on the individual and his or her development. They also suggested that global economic imperatives have caused countries to view themselves as part of a global trading community.

These elements have led to new economic and social institutions that are, as Peters and Waterman (1982) reported, based on respect for the individual who is seen as a source of ideas rather than just as a pair of hands. This new view changes the work and marketplace to a cooperative endeavor in which every person is seen as an important contributor. No longer is one person viewed as better than or above another person. Instead, each person is seen as having a differentiated role with equal importance to the success of society in general or to an enterprise in particular.

EDUCATIONAL REFORM IN THE INFORMATION AGE

Schools and the educational system are always changing, however, Goodlad (1966) suggested that in the school curriculum "the change usually has not been fundamental" (p. 9). Moving from an agrarian focus to an industrial focus required significant shifts in the educational system of America. The curriculum broadened somewhat and extended beyond the intellectual skills needed by the limited numbers of professional people and aristocrats who populated the country up to 1880. A new emphasis on practical education for the common man was promoted across the land. Agriculture/mechanical/engineering colleges or land grant colleges (Morrill Act of 1862) and manual training high schools, starting with the Manual Training High School, St. Louis, Missouri, in 1880, sprang up to meet the demands of the new age. The new practical subjects in the schools, however, were generally given less status than the academic subjects that had enjoyed a long educational tradition.

According to Goodlad (1966), educational change lost much of its focus during the Great Depression and World War II. He stated that "we had lost sight of education as a potential force for societal welfare, and had neglected our schools" (p. 9). According to the results of Armed Forces tests, high school graduates had an appalling lack of scientific and mathematical knowledge. After the Russians launched Sputnik into orbit in 1957, a great educational reform movement, fueled by the National Defense Education Act of 1958, was born. This act was designed to accomplished the following: (a) strengthen instruction in mathematics, science, and foreign language, (b) improve guidance so students would choose careers in these areas, and (c) provide scholarships for students pursuing careers in these areas. It also clearly emphasized the academic disciplines and separate class offerings along the lines of collegiate undergraduate education, namely, mathematics, physical and biological sciences, and foreign languages. Goodlad (1966) summarized this reform movement as "discipline centered rather than child or society centered" (p. 9).

As the American society moves from an industrial (manufacturing/service) economy to one driven by information and knowledge, a shift in the perceptions of the structure of society and the purposes of education and schooling will be required. Toffler (1970) was an early student of this change and suggested that this period could be described as one in which "change is avalanching upon our heads and most people are grotesquely unprepared to cope with it" (p. 12). Later he wrote that these seemingly isolated, violent changes were neither random nor independent (Toffler, 1990). According to Toffler (1980), changes that "produce today's greatest perils also open fascinating new potentials" (p. 19). This condition would require schools to abandon the accumulated knowledge transmission model that has permeated them for decades. A model based on a belief that the future is simply an extension of the past—a predictable evolution of institutions and an extension of present-day events.

New models that develop cooperative attitudes, group participation skills, and an acceptance that learning never ends are needed, but the educational community has been reluctant to address these changing requirements of the new age. The inability to perceive the demands of a new age and the slowness to act has caused a loud voice of criticism to be raised (Boyer, 1983; Adler, 1984; Goodlad, 1984; Sizer, 1984). The harshest criticism was leveled by the National Commission on Excellence in Education (1983) in their report, *A Nation At Risk*, which boldly stated, "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might have viewed it as an act of war" (p. 5). The authors of the report further stated that "Our society and its educational institutions seem to have lost sight of the basic purposes of schooling, and of the high expectations and disciplined effort needed to attain them" (pp. 5–6).

Peters (1987) wrote that during the information-knowledge age, "Nothing is predictable" (p. 9). This unpredictability extends into the schools and speaks directly to curriculum developers and teachers. The facts people need to know are not predictable and neither are the point-of-practice skills.

Feather (1989) suggested that schools in the new age have a specific calling when he wrote that "The world's biggest single requirement, bar none, is to maximize its human potential" (p. 95). This means schools must prepare people to cope with change, address problems never imagined, and deal with radically new institutions. Feather emphasized this point when he suggested that we must place emphasis on learning to learn, whereby people can find their way through ever more complex labyrinths of information. His educational model reflects the thinking of many information age scholars. He would place emphasis on (a) learning to find knowledge, (b) differentiating good information from poor information, and (c) applying knowledge to decisionmaking. This philosophy can be summed up in a new slogan used by many science educators: *less is more.* The slogan captures the thinking of those who advocate a shift from fact-based learning to process-based education. It means less content presented and memorized will mean more learning if the processes of the discipline (observing, describing, reporting, etc.) are stressed.

Educational reform of today may be categorized into three movements. The first of these reform movements, which has been in process for several decades, is a move from fact to concept learning. Goodlad (1966) identified its purpose as follows:

> To organize the fields around primary structural elements of each discipline: the concepts, key ideas, principles, and models of inquiry. This focus assumes that understanding these elements (rather than merely possessing the facts) gives the student the intellectual power to attack unfamiliar problems and enables him [or her] to grasp intuitively the relationship of new phenomena not previously encountered to phenomena already experienced. (p. 15)

Typical of the effort in this area is the recent work with the science curriculum. The National Science Teachers Association (1992) suggested that the science curriculum should present science as a means to achieve the following goals:

> (1) learning about the behavior of the universe and the matter and energy it contains, (2) organizing this knowledge so it is comprehensible and useful to humans, and (3) developing models and theories about this behavior that not only correlates with past observations but also helps predict the future. (p. 19)

A second and more recent curriculum reform movement has placed emphasis on process learning in which the procedures used to arrive at answers are stressed more than the answers themselves. For instance, the mathematics education community has aggressively addressed this approach in their *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989). This document identified 14 key standards around which instruction should focus to produce mathematically literate workers, lifelong learners, and informed members of the electorate. The standards emphasized using mathematical processes in everyday life instead of learning abstract mathematical principles. Similarly, the British technology curriculum (*National Curriculum Council*, 1990), which organizes content primarily around the design or problem solving process, represents a process-based curriculum.

The third reform movement has placed emphasis on integrating subjects. According to Beauchamp (1983), this approach has been tried only once before and that was with Dewey's Progressive Education emphasis on the learner in the school setting. Beauchamp suggested integration of subjects "would not only facilitate learning on the part of the pupil but would additionally make the knowledge, skills, and attitudes more easily available to the pupils in post-school life" (p. 94). Two major integration movements are being encouraged through funding by the National Science Foundation (1992). These are the integration of science subjects (biology, physics, chemistry, etc.) and the integration of mathematics, science, and technology instruction. In most of the approaches currently being developed, hands-on curriculum is being promoted in which students work together in laboratory settings to apply the processes of the disciplines as they investigate and develop solutions to appropriate problems. Often major themes, such as biotechnology, manufacturing, and forecasting (Illinois State University, 1992), are used to integrate the content of the several areas into larger teaching units.

TECHNOLOGY EDUCATION CURRICULUM DEVELOPMENT

As the country emerged from World War II, many curriculum innovators returned to their academic pursuits. To some of the leaders in the profession, the material and process organizers (woodworking, metalworking, drafting) of industrial arts seemed to provide an inadequate base for the field. A search for a more defensible content base for technology education was spearheaded by William E. Warner and his graduate students at The Ohio State University. Their ideas were presented in a significant publication, *A Curriculum to Reflect Technology* (Warner, 1947). Warner wrote the following in the introduction to the publication:

> Primitive man developed the Handicrafts to supply his limited needs of self preservation. The Renaissance of the 14–16th Century brought a wave of invention and the dawn of Industry which is still being launched in underdeveloped areas. Today's economy has become Technological and the resulting problems of productivity and consumption, not to mention the social adjustments involved, have become literally cataclysmic. (p. 3)

Warner's publication suggested the content should be "derived via socio-economic analysis of technology and not by job or trade analysis as of the commoner village trades such as those of the carpenter, the blacksmith, the cabinet maker . . . " (p. 6). He further suggested that the major subject matter classifications should be power, transportation, manufacture, construction, communication, and personnel management (p. 6). Warner's emphases were on technology rather than tool skills and on organizing content on human activity. These provided the early foundations for the technology education movement that would gain momentum during the next several decades.

The initial efforts of William E. Warner were followed by a number of individual efforts throughout the United States. Delmar W. Olson of Kent State University completed his doctorate under Warner's mentorship. His dissertation, which was later published as a book (Olson, 1963), focused on industrial arts and technology and suggested that "technology may well be considered contemporary America's primary resource" (p. 31) because "it provides man's [people's] physical and material needs" (p. 33). Olson further stated that "technology is a record of man's [people's] control over nature" and a "record of man's [people's] ability to create his [their] own environment" (p. 33). He suggested that in studying technology, the content should be derived through an analysis of the functions of personal life which he identified as technical, occupational, consumer, recreational, cultural, and social.

Edward Towers, Willis Ray, and Donald Lux, when developing the Industrial Arts Curriculum Project (IACP) at The Ohio State University, suggested that "industrial arts is a study of industry" (IACP Rationale, 1968, p. 4). The IACP staff determined that there were four domains of human knowledge: formal, descriptive, prescriptive, and praxiological. Praxiological knowledge became the focus of their curriculum and was described as the knowledge of practice. This knowledge was roughly equivalent to the description of technology provided by Warner. The IACP staff built its curriculum on the practices used to change materials to add to their worth and the problems associated with creating these changes. This focus led the IACP staff to conclude that only two activities generate material changes: manufacturing and construction. These two industrial activities became the titles of the two junior high school courses that were developed for the program and later made available to the public through McKnight Publishing Company of Bloomington, Illinois.

At the same time as the IACP curriculum was being developed, Wesley Face and Eugene Flug directed the American Industry Project at the University of Wisconsin-Stout. This curriculum development effort suggested that the central focus of industrial arts was the study of industry and its 13 basic concepts: communication, transportation, finance, property, research, procurement, relationships, marketing, management, production, materials, processes, and energy (American Industry, 1971). The staff structured a program that contained courses for grades 8, 10, and 12. The eighth grade program was developed and field tested before the project lost its federal funding.

Both the IACP and the American Industry Project used industry as the content base. On another front, Paul W. DeVore of the State University Of New York-College at Oswego, started his work on curriculum reform based on technology. DeVore (1966) suggested that industrial arts should be limited to "the study of man [humans] and technology (including the technical and cultural-social elements) as a creative endeavor in meeting the needs of individuals and cultures, in the areas of products, transportation and communication, through the utilization of the properties of matter and energy" (p. 11). He further suggested that a segment of the school curriculum should be organized around technology because it would accomplish the following:

1. Provide an appropriate base to meet the purposes of general education.
2. Extend beyond geographic boundaries.
3. Present humans as the creators of technology regardless of national origin.
4. Provide a vehicle to view the relationship between technology and the culture.
5. Encompass a body of knowledge that can be classified as a discipline.

Another approach to improving industrial arts curriculum was advocated by Donald Maley at the University of Maryland. His primary focus was on the development of the students' abilities and self-perceptions. Maley (1973) suggested the field "is a more complete approach to the development of people because of its integrally woven mental and manual learning processes" (p. 2). The program he advocated was primarily a method of learning and it parted company with other curriculum reforms by its lack of identified content. Maley's (1973) major content parameters were contained in his belief that the curriculum area should "deal with technology—its evolution, utilization, and significance; with industry—its organization, materials, occupations, processes, and products; and with the problems and benefits resulting from the technological and industrial nature of society" (pp. 2–3).

During 1950s, 1960s and 1970s, three new types of industrial arts programs had emerged. These programs were based on the following: (1) industry, as exemplified by the IACP and the American Industry Project; (2) technology, as promulgated by Olson and DeVore; and (3) the needs of the child as derived from Maley's work.

TECHNOLOGY EDUCATION: MEETING OF THE MINDS

Throughout the late 1970s and into the 1980s, professionals in the field spent considerable time debating the suitability of the various curriculum approaches, yet very little was changing in the schools at any level. In a national study funded by the United States Department of Education, Dugger (1980) found that the most commonly offered industrial arts courses were general woods, general metals, general industrial arts, and mechanical drafting. These course titles closely paralleled the course titles of Calvin Woodward's 1880 Manual Training High School. The offerings had little relationship to the technologically based curriculum structures that Warner, Olson, Towers, Lux, Ray, DeVore, Maley and others had been advocating.

A significant step in charting a unified direction for technology education came with the Jackson's Mill Industrial Arts Curriculum Symposium project (Snyder & Hales, n.d.). The project grew out of an effort of the Curriculum Committee of the American Industrial Arts Association (now called the International Technology Education Association) to have the leaders of the three emerging curriculum efforts come together to chart a unified direction for industrial arts. The editors of the resulting document placed this effort in content when they wrote the following:

> It is a rare opportunity when a group of industrial arts educators, much less any other group, are afforded the opportunity to withdraw from their daily activity into an environment dedicated to the purpose of creative thought. So it was that twenty-one members of the industrial arts profession lived the challenge of inquiry, assimilation, compromise and consensus through what has become known as the Jackson's Mill Industrial Arts Curriculum Symposium.
>
> The literature in our field of study over the past few years has been replete with concerns and warnings about the direction and future of industrial arts. Committees within the AIAA structure have issued reports with the same conclusions. It is, therefore, time to translate debate into action. It is time to assess the relationship of industrial arts to comprehensive education. It is time to rededicate ourselves to a common professional cause.
>
> Hence the purpose of this document is to provide rationale and direction for the future industrial arts from which we might all find a point of view. (p. ii)

A group of 21 professionals were selected for the project and they represented all geographical areas of the nation. They included the follow-

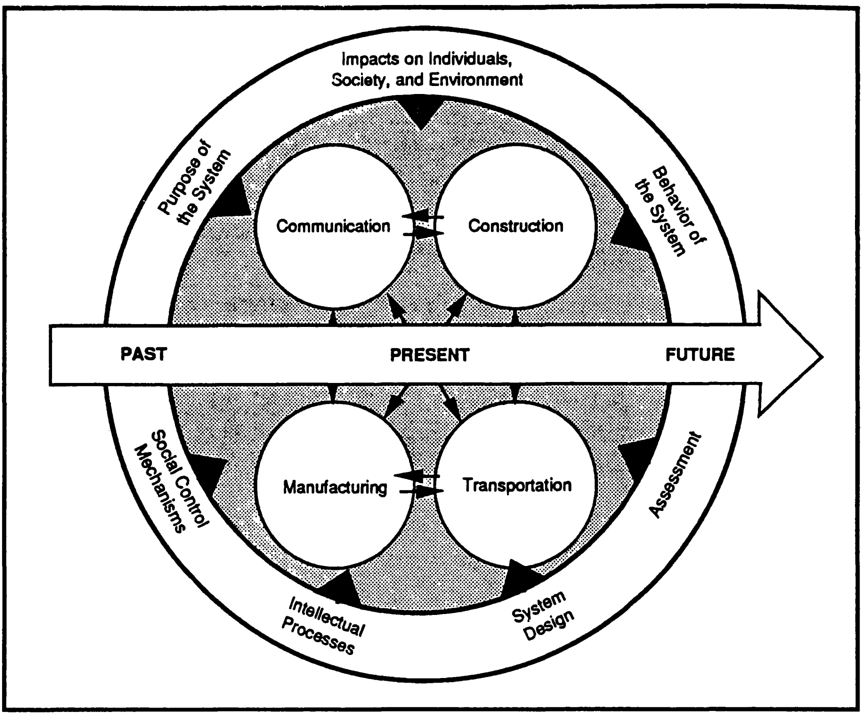

Figure 7-2: The context of human productive activity as content for technology education. (Hales & Snyder, p. 25).

ing people: Myron Bender (North Dakota), James Bensen (Wisconsin), Paul DeVore (West Virginia), William Dugger (Virginia), Frank Field (New Mexico), James Good (New York), James Hales (West Virginia), Norma Heasley (Ohio), Daniel Householder (Texas), Everett Israel (Illinois), Donald Lauda (Illinois), Gary Lintereur (Illinois), Eugene Martin (Texas), Charles Pinder (Virginia), Willis Ray (Ohio), John Ritz (Virginia), Alvin Rudisill (Iowa), Earl Smith (Oregon), James Snyder (West Virginia), Kendall Starkweather (AIAA), and Thomas Wright (Indiana).

The project report, which was the culmination of three meetings over a two-year period, presented a rationale and content structure for industrial arts. Many advocates of this report rapidly changed their programs and the name of their offerings to technology education or industrial technology education. The report presented a model that was based on the human productive activities. This model is shown in Figure 7–2.

The *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, n.d.) document suggested the following key points:

1. The field is the study of technology, industry, and their impacts on society. Technology was defined as "the knowledge and study of human endeavors in creating and using tools, techniques, resources and systems to manage the man-made [human-made] and natural environment for the purpose of extending human potential and the relationship of these to individuals, society, and the civilization process" (p. 2). Industry was defined as "that section of the societal economic institution that utilizes resources to produce goods, services, and information to meet the needs and wants of individuals and society" (p. 2).

2. The study of technology should focus on the human productive activities of communicating, constructing, manufacturing, and transporting because "throughout history people have *manufactured* goods, *constructed* structures, *communicated* ideas, and *transported* goods and people" (p. 23). Communication was defined as "the technical adaptive system *designed by people* to efficiently utilize resources to transfer information to extend human potential" (p. 26). Construction was defined as "the technical adaptive system *designed by people* to efficiently utilize resources to build structures or constructed works on a site" (p. 30). Manufacturing was defined as "the technical adaptive system *designed by people* to efficiently utilize resources to extract and convert raw/recycled materials into industrial standard stock and then into industrial and consumer goods" (p. 33). Transportation was defined as "the technical adaptive system *designed by people* to efficiently utilize resources to obtain time and place utility and to attain and maintain direct physical contact and exchange among individuals and society units through the movement of materials/goods and people" (p. 36).

3. These activities are most easily understood as systems with inputs, processes, outputs, and feedback that operate in a social/cultural setting and impact the society. Inputs to a system were listed as people, knowledge, materials, energy, capital, and finance. Process was considered "a scheme of actions and practices. . . . referred to as the technical means of the system. The knowledge of these technical means is 'technology' " (p. 13).

A follow-up project to the Jackson's Mill curriculum effort was the Industry and Technology Education (Wright & Sterry, n.d.) project which was funded by the Technical Foundation of America. This project accepted

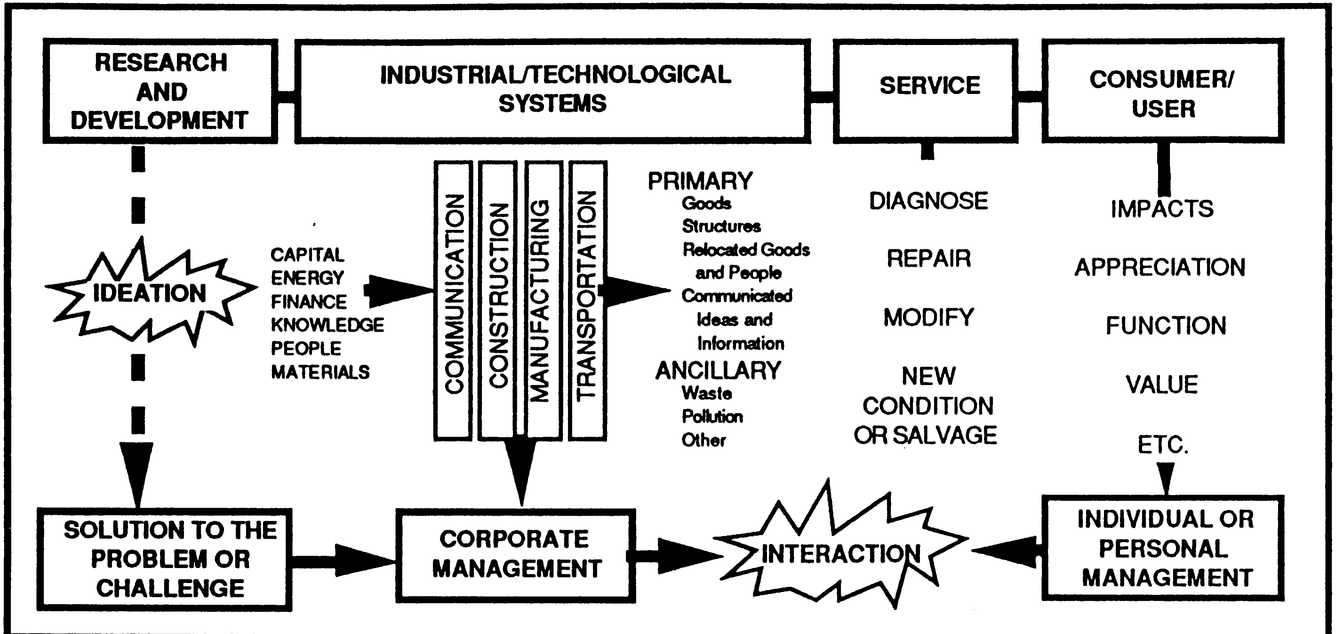

Figure 7-3: The relationships between content elements as presented by the Industry and Technology Education Guide for Curriculum Planners (Wright & Sterry, p. 213).

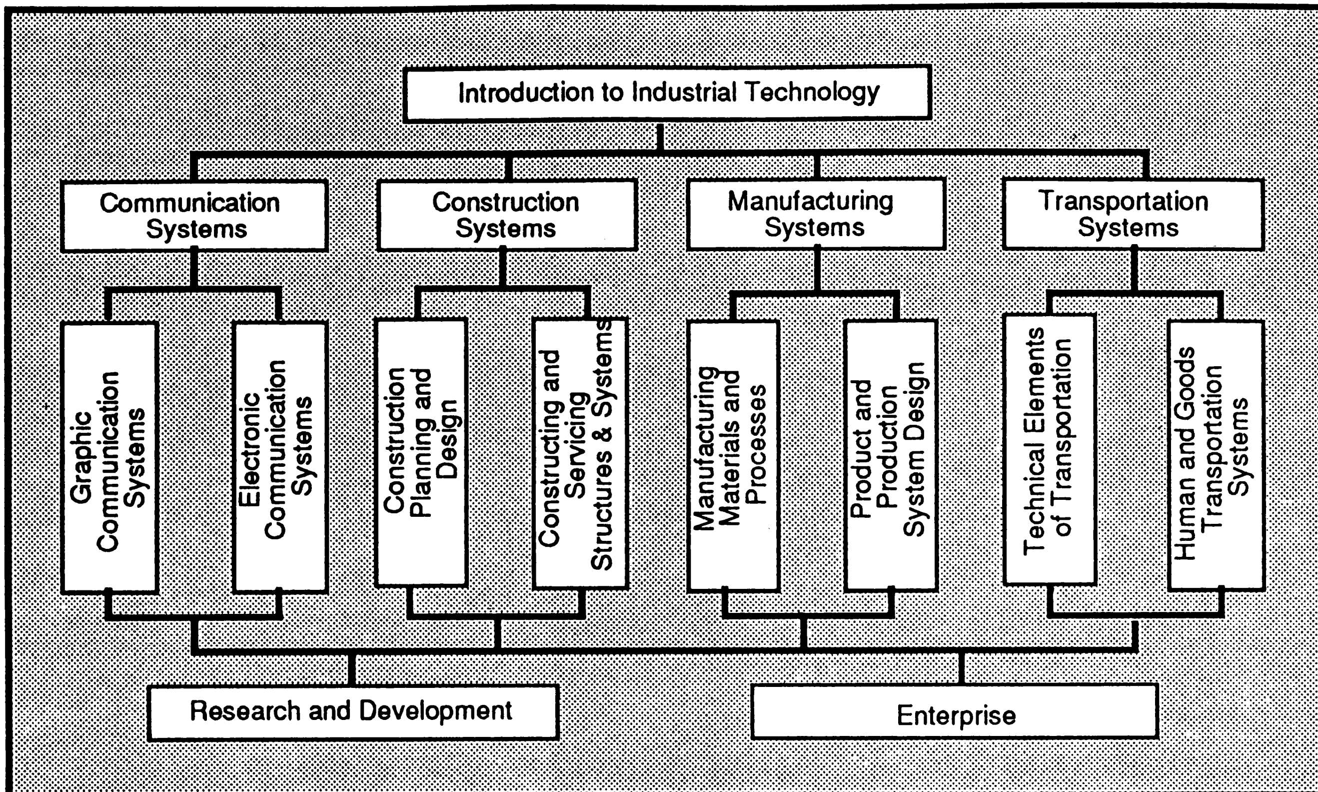

Figure 7-4: Medium-Sized Program Model from the Industry and Technology Education Project (Wright & Sterry, p. 16).

the *Jackson's Mill Industrial Arts Curriculum Theory* philosophy but recognized that it only presented a philosophy upon which to build a curriculum. The directors of the project, R. Thomas Wright of Ball State University and Leonard F. Sterry of the University of Wisconsin-Stout, selected eight people to develop a plan to implement the Jackson's Mill theory. In addition to the directors, the project team included Myron Bender (North Dakota), Keith Blankenbaker (Ohio), James Good (New York), Les Litherland (Colorado), James Bensen (Wisconsin), Frank Field (New Mexico), Robert Habingreither (Texas), and Michael Steczak (Indiana).

The new project developed a model showing the relationships among content elements for the discipline as illustrated in Figure 7–3. This model presented several relationships: (a) the evolution of a product from research and development through consumer use; (b) the relationship among research and development, ideation, and problem solving; and (c) the interaction between personal and corporate management. The model was also the basis for the central focus of the project which included model curriculum structures and basic course outlines for Jackson's Mill-type curricula in small-sized programs (one to two teachers with 160 or fewer students), medium-sized programs (two to three teachers with 160 to 300 students), and large-sized programs (at least four teachers and over 320 students) as shown in Figure 7–4.

A number of curriculum leaders adopted, modified, or extended the ideas contained in the *Jackson's Mill Industrial Arts Curriculum Theory* report and the *Industry and Technology Education: A Guide for Curriculum Planners* or have developed their own perspectives. An example of one of these efforts is New York's recognition that technology is essential content for all students. This recognition resulted in a required broad-based one year technology course for all middle school and junior high school students. The course is made up of a series of teaching learning activities, referred to as TLAs, which include technology topics related to the content found in industrial arts and home economics.

Another new program effort is New Jersey's (Chamuris & Ochse, 1990) curriculum that focuses on problem solving as the major curriculum thrust. A model of their view of the design process is shown in Figure 7–5. The New Jersey middle school program is a series of modules united under the title, Design and Technology. These modules include (a) Introduction, (b) Design/Problem Solving, (c) History/Evolution, (d) Systems, (e) Resources, and (f) Control (Hutchinson, 1988). Their high school program takes on a high-tech emphasis coupled with design. It includes five courses: (a) Invention and Innovation, (b) Video Production and Computer Graphics, (c) Research and Design, (d) Technology and Robotics: Design and Application, and (e) Computer Aided Drafting and Design.

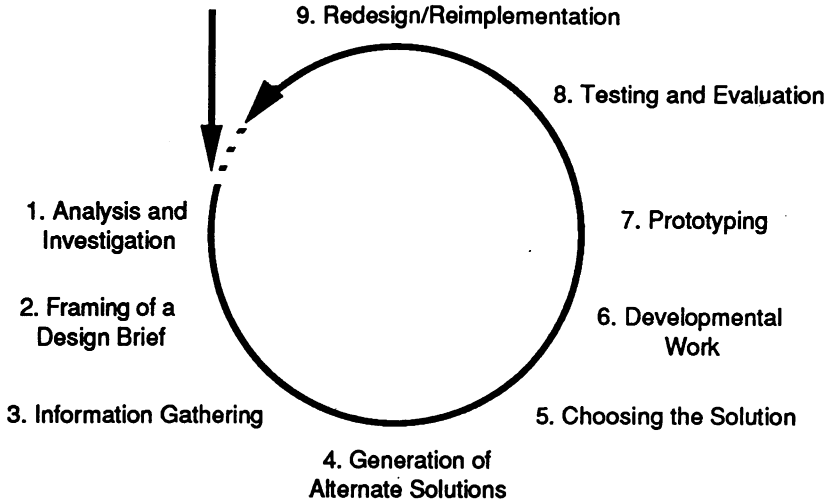

Figure 7-5: A Model of the Design Process Used in the New Jersey Technology Education Program (Chamuris & Ochse, 1990).

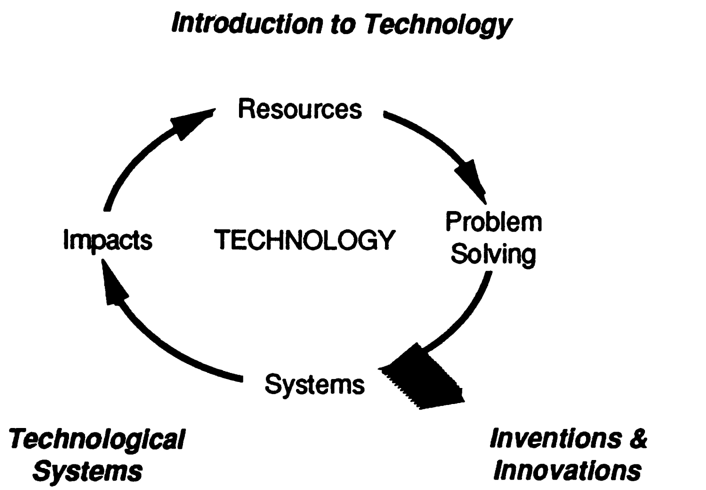

Figure 7-6: Model of the Virginia Middle School Program.

Virginia (Virginia Department of Education, 1989) developed a middle school technology education program that contained three courses: Introduction to Technology, Inventions and Innovations, and Technology Systems. These courses have four recurring components that are considered the basics for technology: resources, processes, systems, and impacts as shown in Figure 7–6.

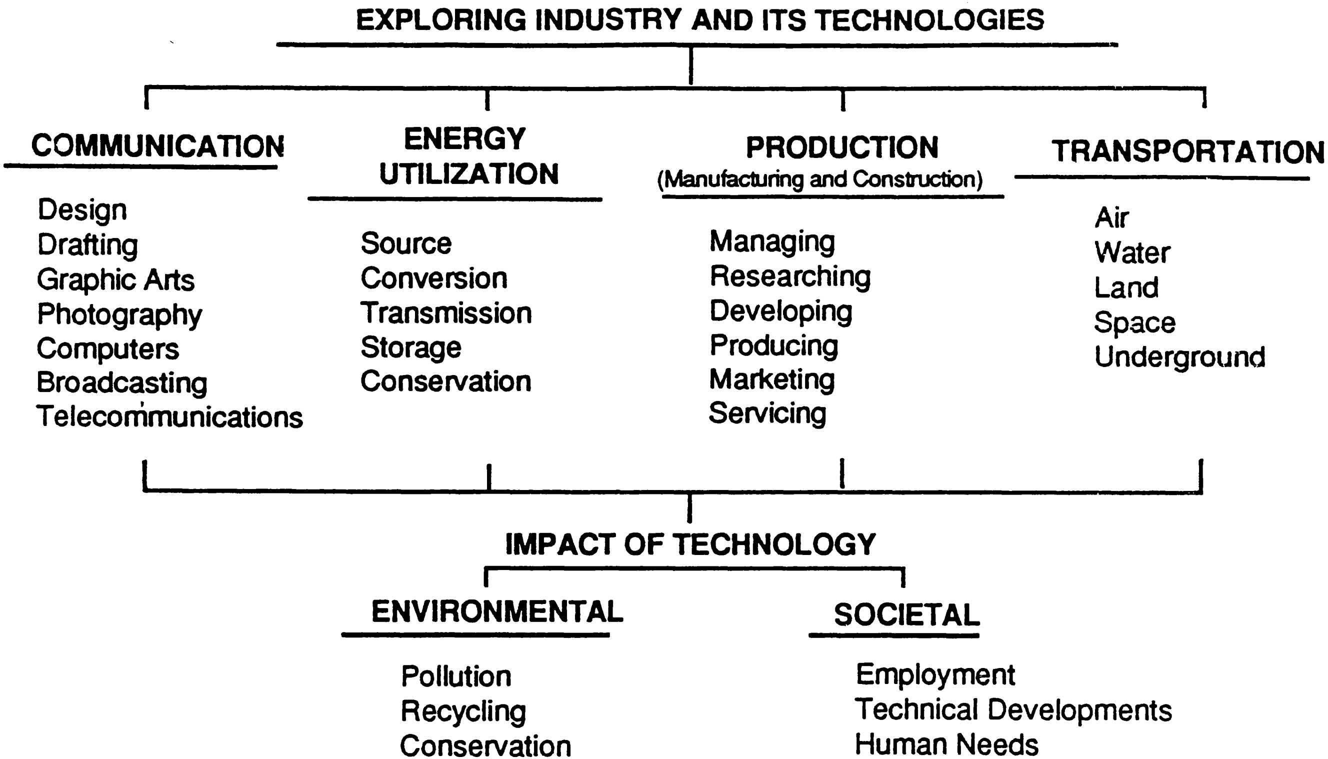

Figure 7-7: Modules for Illinois Junior High School Industrial Technology Curriculum (Illinois State Board, 1983, p. 14).

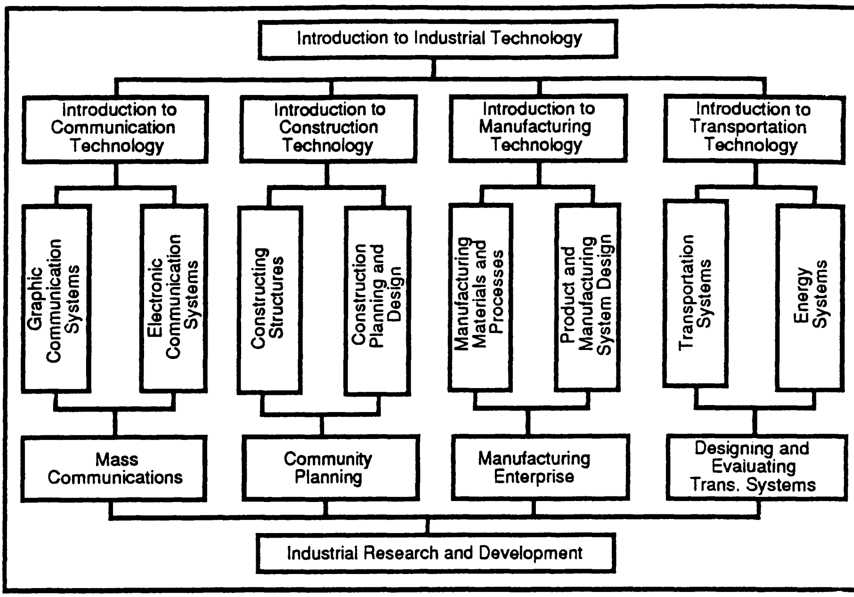

Figure 7-8: A Model of the Indiana Industrial Technology Education Program (Indiana Industrial Technology Education Program Guide, 1985).

Illinois (Illinois State Board of Education, 1989) developed middle school and high school industrial technology education programs that emphasized communication, energy utilization, production, and transportation technologies. The middle school program includes 24 three-week modules that can be assembled into courses as shown in Figure 7–7. Some of the modules, such as drafting, graphic arts, and photography in the communication module, are somewhat traditional while others, such as computers and telecommunications, are strongly technology oriented. The 9th and 10th grade levels in the high school program allow students to study the four curriculum organizers in separate courses that emphasize resources, technical processes, industrial applications, and technological impacts. The last two years of high school include advanced technical studies and vocational programs.

Indiana implemented an articulated 6th through 12th Grade curriculum patterned after the *Industry and Technology Education: A Guide for Curriculum Planners* Medium School Model. Their 18-course offering was organized around communication, construction, manufacturing, and transportation technology as shown in Figure 7–8.

A number of other states have developed their unique technology offerings. Most of them used the Jackson's Mill curriculum organizers of communication, construction, manufacturing, and transportation. A few states merged manufacturing and construction under the term production. In every case the implementation of the program was relegated almost exclusively to middle/junior high school and high school levels. Little was done in the elementary school for a number of reasons including (a) lack of expertise by the curriculum developers, (b) difficulty in convincing elementary teachers to include technology in their instructional plans, and (c) limited human and financial resources to develop the curriculum and to train teachers.

TECHNOLOGY EDUCATION: NAME AND GOALS

Each of the new technology education programs had unique objectives with technological literacy being a common theme in most programs. This emphasis is seen in Illinois' overall goal statement for Industrial Technology Education (Illinois State Board of Education, 1989) "to help students become technologically literate and equipped with the necessary skills to cope with, live in, and work in a highly industrial/technological society" (p. 7).

Virginia's (Virginia Department of Education, 1989) goals for their middle school technology education program called out what technological literacy would entail. Specifically, the goals suggested that after completing a middle school technology education program, students would be able to accomplish the following:

1. Identify the historical, current, and future development of technology and their impacts and potential on earth and in space.
2. Apply critical thinking processes to solve technological problems.
3. Use tools, materials, and processes safely and efficiently.
4. Strengthen creative abilities, positive self-image, and individual potential in technology.
5. Explore occupations and educational programs for technology-oriented careers.

Illinois' overall goal and Virginia's specific objectives seem very compatible even though these states' programs had different names. The Illinois program was called Industrial Technology Education while the Virginia program was called Technology Education. The difference in nomenclature within the profession led to a major debate during the 1980s and early 1990s. A number of people fell into a trap of deciding that anything with the adjective "industrial" must focus on skills and was, therefore, at least perpetuating the past and was at worst vocational education masquerading under another name. The reality was that the scope and emphasis of technology education varied from program to program and had little to do with what it was called.

Some states' programs simply changed their names from industrial arts to technology education with little or no change in content or instruction. An example of this type of name change only was the early curriculum change work in Colorado. The state association was concerned with satisfying both industrial arts and technology teachers. They also believed that technology education could slowly evolve from an industrial arts program through several phases. The *Technology Education: Implementation Guide for Colorado* (Colorado Industrial Arts/Technology Education Association, n.d.) used communication, construction, manufacturing, and transportation titles but suggested that "careful reading of this document will reveal many evolutionary similarities with traditional programs" (p. 3). This approach to encourage technology education to grow slowly out of existing industrial arts programs led the Colorado developers to list many very traditional industrial arts courses in their technology education program. These courses included wood manufacturing technology, metal manufacturing technology, electronics technology, drafting technology, engineering and architecture technology. Other states with the industrial prefix made significant curricular changes. The industrial technology education programs developed in Illinois, Indiana, and Wisconsin were typical of this movement.

Another recent theoretical model for technology education was developed for the Ohio Model Schools Project (Savage, 1989). This model, shown in Figure 7–9, suggested that technology is the "knowledge and study of human endeavors in creating and using resources, processes, and systems to manage the artificial and natural environment, to expand human potential, and enhance the relationship of these to individuals and society" (p. 2). The program utilized different technological content organizers than had been used in the Jackson's Mill-based movement. It suggested that there are three technological systems:

1. Communication technology system—the technology that involves the use of devices and methods to collect, process, store, or deliver information using electronic, graphic, photographic, and/or mechanical means.

Elementary Grades	Middle Grades	Secondary Grades
Grades K -5 Units in: Systems operations Current operations Environment History	Grades 6 - 7 (20 weeks of instruction) History Development Systems Resourses Problems Solutions	Grades 9 - 10 Communication technology Physical technology Bio-related technology Ergonomics Computers in technology Construction Manufacturing Grades 11 - 12 Technology in society Special problems

FiF

Figure 7-9: A model for the Ohio Model Schools technology education program.

2. Physical technology system—the technology involving the construction or production of products, transportation of materials, and distribution of energy.

3. Bio-related technology system—the practical application of biological organisms to make or modify products.

This work provided the stimulus for a 1989 Technical Foundation of America funded project which was co-directed by Ernest N. Savage of Bowling Green State University and Leonard F. Sterry of University of Wisconsin-Stout. This project was designed to bring a new consensus of direction to the field much as the Jackson's Mill project has done 10 year earlier. Twenty-five participants were selected by the two co-directors and three trustees of the project. The participants were Myron Bender, University of North Dakota; Sharon Brusic, Virginia Polytechnic Institute and State University; Robert A. Diaber, Triad High School (Illinois); William E. Dugger, Jr., Virginia Polytechnic Institute and State University; Thomas Erekson, University of Maryland; Michael Hacker, New York State Department of Education; Daniel Householder, Texas A&M University; Thomas Hughes, Virginia State Department of Education; Everett N. Israel, Eastern Michigan University; Donald P. Lauda, California State University-Long Beach; Jane Liedtke, Illinois State University; Franzie Loepp, Illinois State University; David McCrory, West Virginia State University; John Pannabecker, McPherson College; John Ritz, Old Dominion University; Ernest N. Savage, Bowling Green State University; Anthony Schwaller, St. Cloud State University; Michael Scott, The Ohio State University; Kendall Starkweather, International Technology Education Association; Leonard F. Sterry, University of Wisconsin-Stout; Ronald Todd, Drexel University; Walter Waetjen, Cleveland State University, John R. Wright, Central Connecticut State University; R. Thomas Wright, Ball State University, and Karen F. Zuga, The Ohio State University.

The results of the project were published by the International Technology Education Association in a booklet titled *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990). The report suggested that humans satisfy their needs and wants by applying the problem solving process to change resources into desired outcomes. These actions, according to the report, use four major types of technological processes: bio-related processes, communication, production, and transportation. The report provided a perspective on the scope of technology education but failed to provide a program or course model that would suggest ways to deliver the program's content.

IMPACTS OF BRITISH TECHNOLOGY EDUCATION

Parallel to the technology education curriculum developments in the United States there were similar curriculum development efforts in other countries. The one effort that had the greatest direct impact on the United States was a program developed for the countries of England and Wales. The British technology curriculum, like the one developed in the United States, may be characterized as evolutionary. According to Potter (1990), up to 1970 their program was called craftwork and emphasized tool skills and technical knowledge much like our industrial arts program. The instruction was delivered through the project method where students built useful items. In 1970 a new, broader program, called Craft Design and Technology (CDT) was introduced. It added a central focus on designing to the building aspect of craftwork classes. Central to this program was the design process that, according to Dunn (1986), included the following elements:

1. Design brief or problem
2. Investigation
3. Ideas
4. Develop idea(s)
5. Working drawing or model
6. Make
7. Test (p. 5)

In 1990 a new national curriculum was developed and required in all primary and secondary school grades. One of the major areas in this curriculum is technology which includes two divisions: (a) Design and Technology and (b) Information Technology. The technology program includes the faculties of craft design technology, business education, art, home economics, and information technology (Breckon, 1990).

Design and Technology (D&T) is expected to be taught through themes and projects in the primary school and as a separate subject in the secondary school. D&T instruction is couched within home, school, recreation, community, and business and industry contexts and explores an interrelationship among environments, artifacts, and systems as shown in Figure 7–10. These three elements, according to Potter (1990), were defined as follows:

1. Environment: Surroundings made or developed by people.

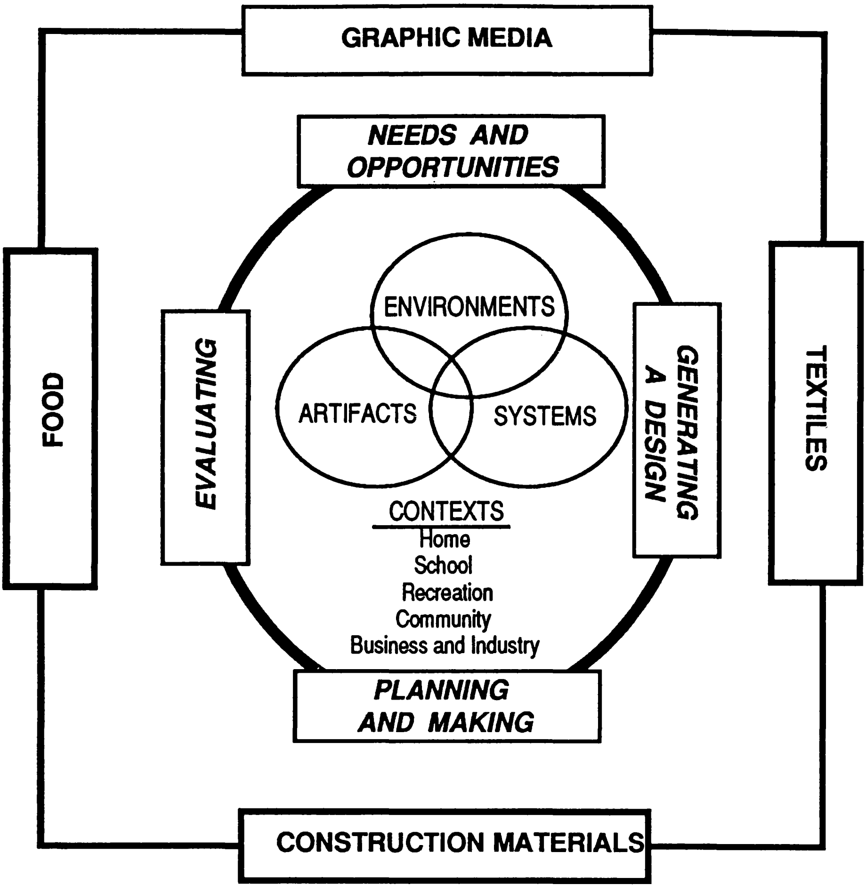

Figure 7-10: A Model of the British National Curriculum for Technology (Adapted from a Transparency developed by Clive Potter, 1990).

2. Artifact: An object made by people.

3. System: A set of objects or activities that together perform a task.

Design and Technology includes four basic areas: construction materials, food, textiles, and graphic media (London, 1991). Each of these areas focuses on four attainment targets (AT) which are the major organizers of the curriculum. These targets and their objectives were described by the National Curriculum Council (1990) as follows:

AT1 – Identifying needs and opportunities

Pupils should be able to identify and state clearly needs and opportunities for design and technological activities through investigations of the contexts: home, school, recreation, community, business and industry. (p. 3)

AT2 – Generating a design

Pupils should be able to generate a design specification, explore ideas to produce a design proposal and develop it into a realistic, appropriate and achievable design. (p. 7)

AT3 – Planning and making

Pupils should be able to make artefacts (sic), systems and environments, preparing and working to a plan and identifying, managing and using appropriate resources, including knowledge and processes. (p. 11)

AT4 – Evaluating

Pupils should be able to develop, communicate and act upon an evaluation of the processes, products and effects of their design and technological activities and of those of others, including those from other times and cultures. (p. 15)

Through its four attainment targets, the British curriculum emphasizes design to the near exclusion of the production/commercialization of the developed technology. This marked difference from the American emphasis on technological systems and processes has caused many leaders in the United States to re-examine their stand on the scope of the field. Many American technology educators came to recognize that their production emphasis without a balanced design emphasis provided an incomplete view of technology. They also realized that the Americans' unwillingness to recognize technology as an essential subject for all grades deprives students of the opportunity to explore this vital subject during their formative years.

TECHNOLOGY AND TECHNOLOGY EDUCATION

Some of the great differences in programs can be explained by a vague understanding of the term technology among curriculum innovators and critics. It is apparent the ever-present, unavoidable, potentially beneficial phenomena called technology has been widely misunderstood, inaccurately defined, and often distrusted. To some people, technology is hardware. It is computers, lasers, and supersonic aircraft. To other people, technology is organization. It is the way people structure themselves to produce products and services. To still other people, technology is process. It is the actions used in developing, producing, and using artifacts.

A primary problem is in confusing these views. Those holding the first view of technology developed high-tech industrial arts programs that they called technology education. They replaced drawing boards and T-squares with CAD terminals and wood lathes with CNC lathes. The students still mastered skills, but now they were high tech skills.

Those holding the second view of technology talked about "they" as if industrial or managerial organizations were responsible for the woes of society. The focus of these technology education programs became a social studies-type study of the impacts of technology. Students researched and reported on technological impacts of people, societies, and the environment. Little time was spent studying the actions used in creating, producing, and using technology.

The last view of technology was accepted by most technology education curriculum innovators as being the broadest and most descriptive. It suggests that "technology is a body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment" (Wright & Lauda, 1993).

The Project 2061 report (Johnson, 1989) captured the essence of technology by suggesting that it is "the application of knowledge, tools, and skills to solve practical problems and extend human capabilities" (p. 1). The report further suggested that technology "is conceived by inventors and planners, raised to fruition by the work of entrepreneurs, and implemented and used by society."

TECHNOLOGY EDUCATION: REDEFINED AND REDIRECTED

As the profession prepares to enter the 21st Century, technology education is receiving a new emphasis. In its curriculum materials development program announcement, the National Science Foundation (1992) singled out technology for one of its three areas of special attention. The National Science Foundation suggested that "technology is not an instrument, but a field of study. It involves the application of learned principles to specific, tangible situations. Problems in technology typically consist of three components: a given set of resources, given conditions or 'constraints,' and stated goals" (p. 3). Similarly, the SCANS Report (United States Department of Labor, 1992) listed five competencies that encompass traditional technology education content. These competencies were as follows:

1. Resources: Identifies, organizes, plans, and allocates resources.
2. Interpersonal: Works with others.
3. Information: Acquires and uses information.
4. Systems: Understands complex interrelationships.
5. Technology: Works with a variety of technologies. (p. 2–3)

These and other initiatives have opened the door for innovative technology education programs, but looking into the crystal ball to predict the possible structure of 21st Century technology education is difficult. There appear to be at least three distinct possibilities. First, several of the states may continue to implement the Jackson's Mill model that focuses primarily on "doing" technology. Second, some states may continue down their path in implementing the British model of "creating" technology using the design, problem solving model. Third, a more promising approach that has received increased attention involves developing a more universal type of technology education for the Year 2000 and beyond (Wright, 1992). This approach abandons types of technologies or the design process as curriculum organizers and uses technological actions to drive curriculum development efforts. It accommodates a large number of contexts for technology, including (a) the Jackson's Mill communication, construction, manufacturing, and transportation; (b) the Savage (1989) bio-related, communication, and physical technologies; and (c) the Dutch (Wolthers, 1989) pillars of technology: energy, information, and matter (materials).

TECHNOLOGICAL ACTIONS AS A NEW ORGANIZER

The technological actions approach views technology as systems that process inputs to create the human-built world. This approach explores the four major actions that are encountered as all technological systems are developed and used: (a) designing and engineering technological artifacts and systems, (b) using tools and machines in producing the system or artifact, (c) using the products of technological systems to meet human needs and wants, and (d) assessing the impacts of technology on people, society, and the environment (Indiana Technology Education Curriculum Committee, 1992; Wright, Lauda, & Israel, 1993).

The technological actions approach accommodates the various views and emphases found in the United States and abroad. The developing phase deals with the British emphasis on creating new technology while the producing phase deals with the focus most common in the United States—applying technology to communicate information, to produce products and structures, and to transport people and goods. The using phase adds the third critical aspect of applying technological devices and systems appropriately to meet human needs and wants. The assessing phase brings into focus an area that most technology educators have embraced but done little to implement in classroom instruction: determining which of the technologies that are available are appropriate and effective.

Another way to view these four phases is that the developing phase studies how new technology is created, the producing phase explores how the accumulated body of knowledge of technology is used to make technology available to people, the using phase deals with the application of technological products and services to human goals, and the assessing phase determines the appropriateness and value of specific technologies. The four phases are shown in Figure 7–11.

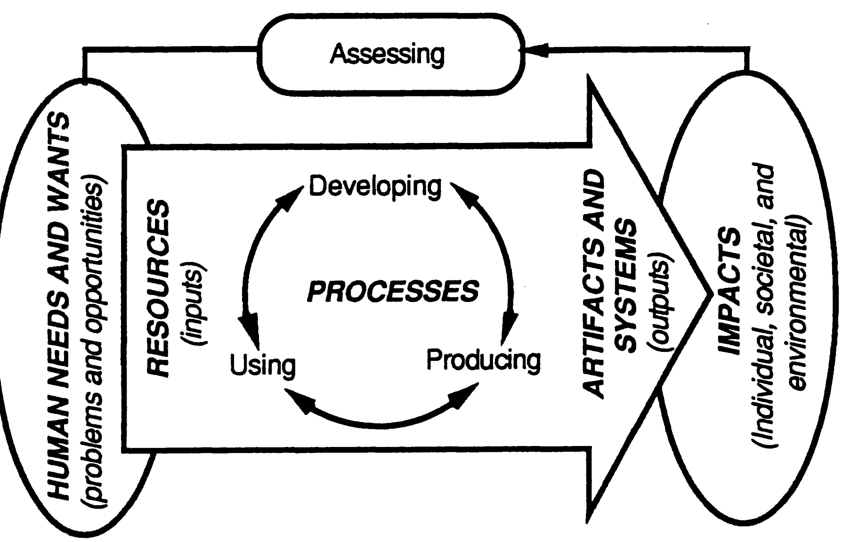

Figure 7-11: Scope of Technology Education (Wright, Israel, & Lauda, 1992, p. 9).

TECHNOLOGY EDUCATION: LOOKING AT SYSTEMS MODELS

Systems as curriculum development tools became more widely used after the Jackson's Mill document was released (Snyder & Hales, n.d.). It suggested that, in a system, the elements relate in an orderly, predictable way. This idea was graphically presented in a "universal systems model" that was composed of inputs, processes, outputs, and feedback. The universal systems model is shown Figure 7–12.

This model can be more accurately described as a production systems model. It depicts the sequence of events used to produce an artifact or service. The model loses its power when it is applied to other technological actions such as developing technology, using technology, or assessing technology. The technological actions approach looks at each technological action (developing, producing, using, and assessing) as a unique sub-system with its own sequential actions.

Developing Technology

The technological actions approach recognized that all technology is the result of purposeful action, that is, of human volition. It communicates that technology starts in someone's mind in response to an identified opportunity or problem needing a solution. This approach would use a systems model to depict the most common technique studied in technology education: problem solving or design. Waetjen (1989) suggested that this process had six steps: (a) Define the problem, (b) Re-form the problem, (c) Isolate the solution, (d) Implement the plan, (e) Restructure the plan, and (f) Synthesize the solution. In *A Conceptual Framework for Technology Education*, Savage and Sterry (1990, p. 14) described the same process as including (a) Defining the problem, (b) Developing alternate solutions, (c) Selecting a

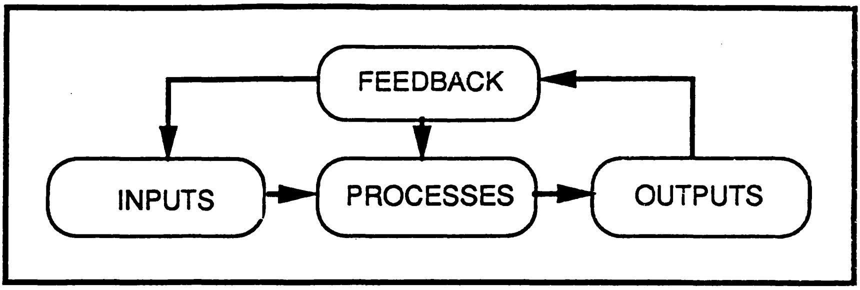

Figure 7-12: Jackson's Mill Universal Systems Model.

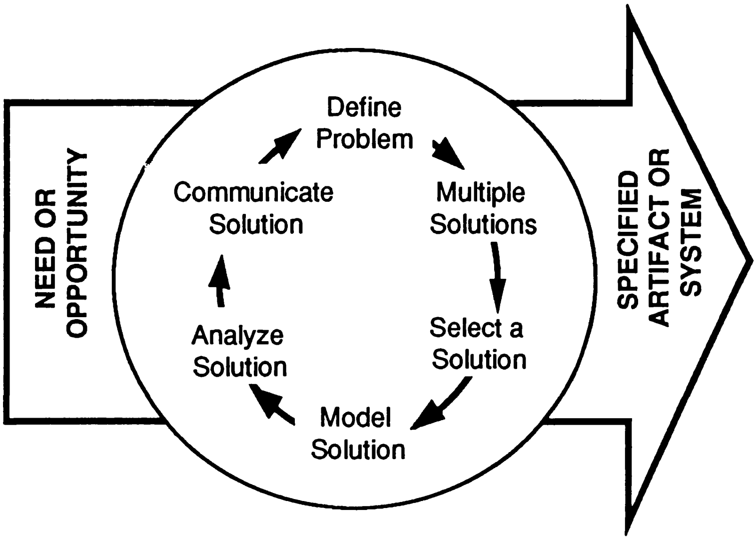

Figure 7-13: A systems model for the technological design process.

solution, (d) Implementing and evaluating the solution, (e) Redesigning the solution, and (f) Interpreting the solution. The four attainment goals (identifying needs and opportunities, generating a design, planning and making, and evaluating) for the British Design and Technology curriculum likewise structured this design process.

In all these system models there are a number of generalized steps that move an idea from a designer's mind into a specified artifact or system. Figure 7–13 shows a generic technology design model.

Producing Technology

The technological actions approach to technology curriculum development recognizes that there exists a vast body of accumulated knowledge that is used to operate technological systems to produce an artifact or service. This knowledge is used to build products, erect structures, communicate information, and transport cargo.

The knowledge of producing is unique for each technological endeavor. The Jackson's Mill systems model is appropriate to give an overall view of these producing actions. Separate sub-systems models, however, are needed to show the unique activities within each specific technological context. For example, the system used to produce a manufactured good involves the knowledge and actions of securing material resources, producing standard

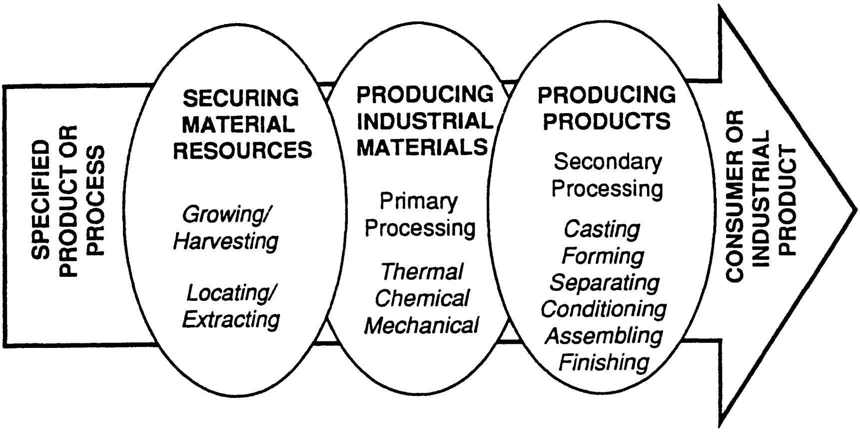

Figure 7-14: A manufacturing production model.

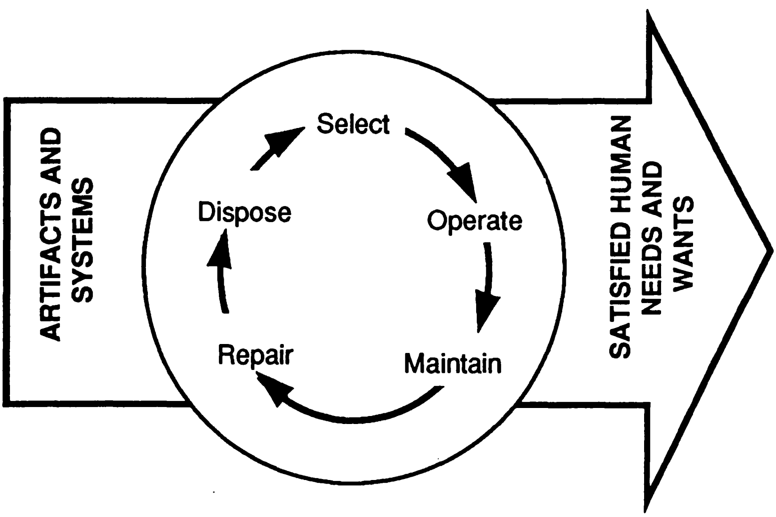

Figure 7-15: Systems model for using products.

stock, and producing products as shown in Figure 7–14. Transporting involves loading, moving, and unloading. Communication processes include encoding, transmitting, receiving, storing, retrieving, and decoding. Constructing involves preparing sites, setting foundations, erecting structures, and finishing sites.

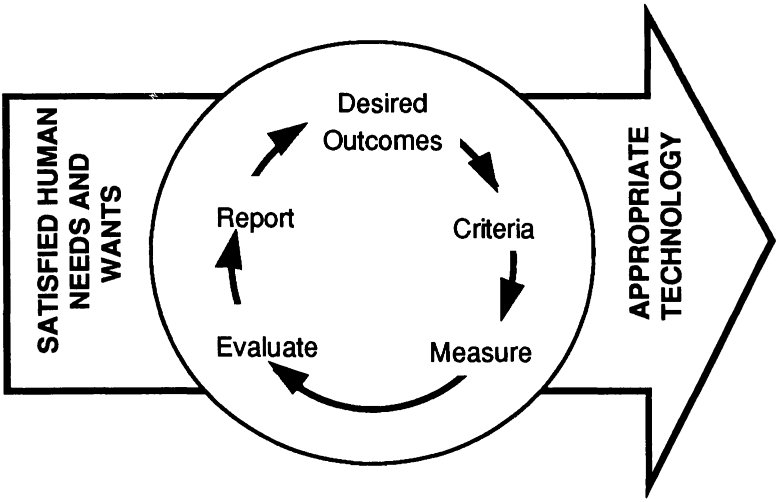

Figure 7-16: Systems model for assessing products.

Using Technology

Few technology education programs have addressed the major element of applying technology to meet human needs. The technological actions approach addresses this deficiency by recognizing that people use technological knowledge and artifacts to meet the demands associated with their career, consumer, and citizen roles in society. As people use technology, they consciously or unconsciously use a systems approach. The approach is different if they are using a technological artifact (product or structure) or a service (transport or communication).

Using the products of technology requires five basic actions. People select, operate, maintain, repair, and dispose of physical items as shown in Figure 7–15. On the other hand, technological services such as transport and communication media have fewer actions. They are first selected and then used. Some communication products such as magazines and newspapers must be disposed of when they no longer serve their purpose.

Assessing Technology

The technological actions approach recognizes that applying technology involves more than just meeting human wants. Technology must also fit within the social and political systems and be in harmony with the environment. This requires that only effective or appropriate technology is used. The parameters that describe what is appropriate, however, change as political, economic, environmental, social, and technological knowledge, goals, and values change.

Selecting the most appropriate technology involves the systematic actions of (a) describing the desired outcome, (b) determining measurement criteria for that outcome, (c) measuring and evaluating the technology's performance, and (d) making recommendations for its use as shown in Figure 7–16.

SUMMARY

Technology education has evolved from an idea in reformers' minds to a reality in the schools of America. Early programs were based on skill development and technical knowledge acquisition, however, these programs became less adequate as society moved from the industrial age into the information age. Innovators, led by William E. Warner, suggested that a new content base, called technology, be adopted. Many people in the profession have suggested ways to move industrial arts from its skill orientation to a technology base. Included in these suggestions were a number of innovative programs developed during the 1960s that used industry as the content base. Among the early curriculum development efforts were the Industrial Arts Curriculum Project and the American Industry Project.

The industrial content base of these programs was challenged by two other movements: Donald Maley's child-based industrial arts and Paul W. DeVore's technology education philosophy. The differences among the industrial, technology, and child-based views were addressed by the Jackson's Mill project that reached a compromise philosophy. This philosophy suggested that industrial arts was a study of technology and industry and the impacts of these two phenomena. The ensuing compromise gave impetus to programs that studied technology and industry as systems under four major content organizers: communication, construction, manufacturing, and transportation.

The Jackson's Mill work is now viewed by some leaders as being too narrow in its perspective. The British work with design and problem solving instruction suggests that beyond the content of technology there are processes used to develop new technology. This merging of content and development processes was addressed in the publication *A Conceptual Framework for Technology Education* that (a) presented a technological method as the process for creating technology, and (b) organized the existing content of technology around bio-related, communication, production, and transportation technologies.

The leaders of the technology education field cannot rest on past accomplishments. Constant change is the hallmark of society and must be the guiding principle for curriculum developers and educators. A new approach that is now starting to be addressed organizes the content and processes of technology under four major technological actions: designing, producing, using, and assessing. This approach may be yet another step in a field attempting to communicate to youth the dynamics of technology.

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CHAPTER 8

Communication Technology Education

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As the 20th century draws to a close, we will have witnessed the most dramatic change in the history of our ability to communicate or to exchange information. Prior to this century, formal communication methods were confined to written or printed forms, photographs or art work, telegraph or basic transmitted signals, and simple audio methods such as the phonograph. Through further development and the integration of multiple technologies and systems came the ability for humans to communicate with each other in new ways, for humans to communicate with machines, for machines to communicate with humans, and for machines to communicate with other machines, all with phenomenal accuracy and speed.

It is no wonder that when I talk with my grandmother who was born in 1901, her mind is boggled by today's lifestyle. It isn't senility or lack of intelligence that causes her confusion. It is merely the extensive amount of knowledge and the major adjustment in thinking that is required to cope with all the interconnected events that have brought us to where we are today. She has witnessed the electrification of homes, the installation of telephone systems, the development of radio broadcasting, and the invention of black and white and then color television. She has lived through changes to computerization, satellite communication systems, fiber optics, lasers, X-ray and other imaging technologies, cellular telephone systems, and a whole host of digital technologies she doesn't even know exist. Ask her what a hologram is or, better yet, how it is created and she'll be quite frank with you—she doesn't have a clue!

The daily lives of people have become dependent upon a vast network of devices that enable them to communicate quickly and efficiently. Many communication technologies and systems employed are beyond their grasp as everyday citizens. They place a lot of trust in communication systems, whether they be fire alarm systems in major office buildings, satellite communications used to report world news, air traffic control systems, fiber optic networks, or personal computers linked to on-line databases. The effectiveness and impact of those systems which people do have direct contact with is based on their knowledge and understanding of how they function and the purposes they can serve.

As educators, we prepare students who will live in an information intensive society, a global society where information has incredible value much like products did in the past. We must provide students with the knowledge and understanding that they will require to utilize and apply the vast changes evident in the communication methods of the future.

> To participate fully in the information age, young adults should understand at least conceptually the technologies that are behind modern communications. Further, they should be aware of the ideas, risks, and benefits of information management that are made possible by advancing communication technology. (Johnson, 1989, p. 23)

DEFINING THE TERMINOLOGY

Communication has been described as the process of sending and receiving messages (Sanders, 1991). As educators, our need for defining what communication is has been extended in order to provide structure to the design of curricula and to facilitate instruction. The definition has also been influenced by the increased sophistication of communication methods and the desire to represent more accurately what actually occurs in the act of communicating. The American Association for the Advancement of Science (1989) stated, "Communication involves a means of representing information, a means of transmitting and receiving it, and some assurance of fidelity between what is sent and what is received. Representation requires coding information in some transmission medium" (p. 95).

Communication technology refers to the technical means (devices and processes) associated with communication. Brusic's (1990) definition combined the definitions of communication and of technology: "Communication technology refers to the tools, techniques, knowledge, choices, and decisions associated with sending and receiving information" (p. 8). According to Johnson (1989), "Continuous technological change is a special attribute of communications technology" (p. 22).

Communication systems are the interrelated and interacting technologies (devices and technical methods) that enable communication to occur. Given

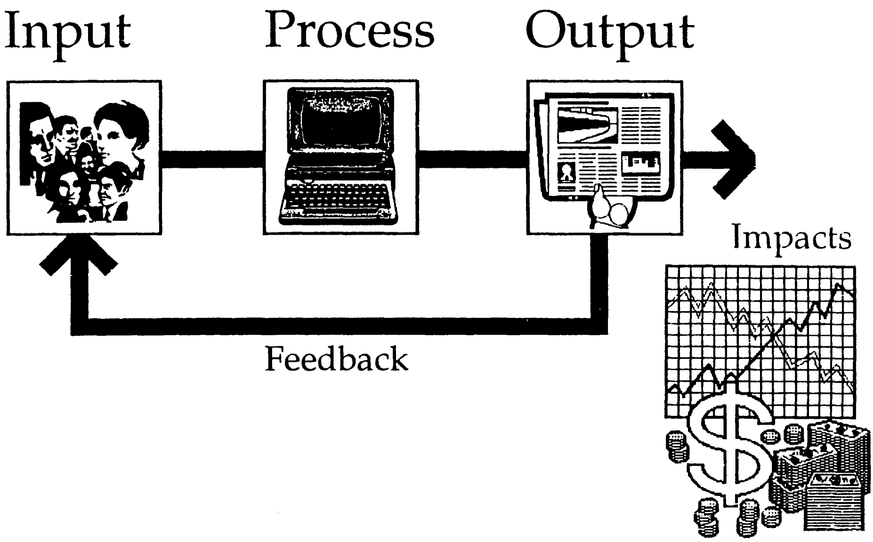

Figure 8-1: Universal Systems Model.

that the Universal Systems Model (see Figure 8–1) is widely accepted as a means of representing systems appropriate to our field, any communication system can be explained in terms of the inputs, processes, and outputs that comprise this model. Most people would agree that a feedback loop is usually in place when systems are functioning (well or otherwise) and that systems have impacts (e.g., societal, economic, environmental).

Inputs usually include ideas, data, signals, and information that must enter the system and be converted or processed into other forms so that they can be outputs in usable versions, formats, or end products. The communication process has become more complex yet is easily described using either the Universal Systems Model or a communication process model. Examples of these include the Linear Model of Communication Technology, as shown in Figure 8–2, or the Composite Model of Communication Technology (Hendricks & Sterry, 1989, p. 112), as shown in Figure 8–3. Both models adequately represent and depict how, in a technical sense, interacting technologies facilitate communication. Both models use the concepts of encoding messages or information as input to the system, with transmitting, receiving, storing, and retrieving as the process portion of the model, and finally decoding as the output segment. Whichever model is selected for use in curriculum planning, the important aspect of applying systems models is to be consistent and use terminology, procedures, and methods of applying the communication concepts in a reliable fashion.

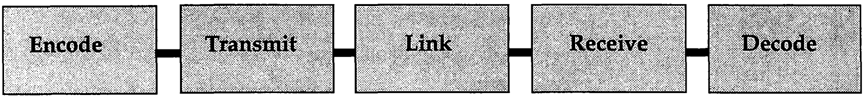

Figure 8-2: A linear model of communication technology.

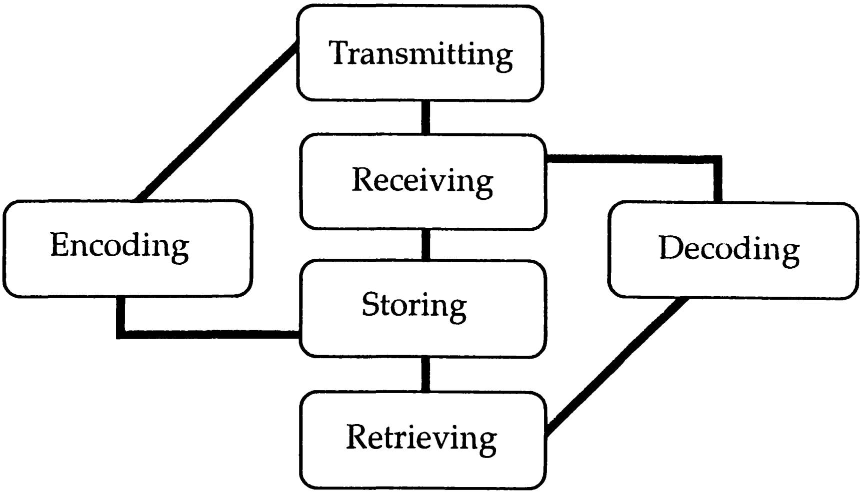

Figure 8-3: A composite model of communication technology. (From Communication Technology *by Hendricks & Sterry)*

Communication via cellular telephone (see Figure 8–4) is an excellent example of the communication system model in application. Let's imagine that a person is driving through a city with the cellular telephone in the car and the codes and number she/he wishes to call are selected. The unit within the automobile sends a signal to a tower that receives the signal and transmits it to the telephone company, which then processes this information through either traditional land-based telephone technologies or across fiber optic, microwave, or satellite communication devices. The signal travels until it reaches the receiving station, where it is converted to a form that is compatible with the individual whom the person intended to receive the call. If he/she is at home, then traditional telephone carrier lines might bring the signal to the telephone unit. If the person is driving in her/his car with a cellular phone, then a transmitting tower may send the signal to the driver's unit, where it is received and decoded for the person to be able to understand the message. As the individual receiving the call talks back, the process works in reverse. A system is being utilized to communicate and it is dependent upon a series of technologies, interrelated systems and devices,

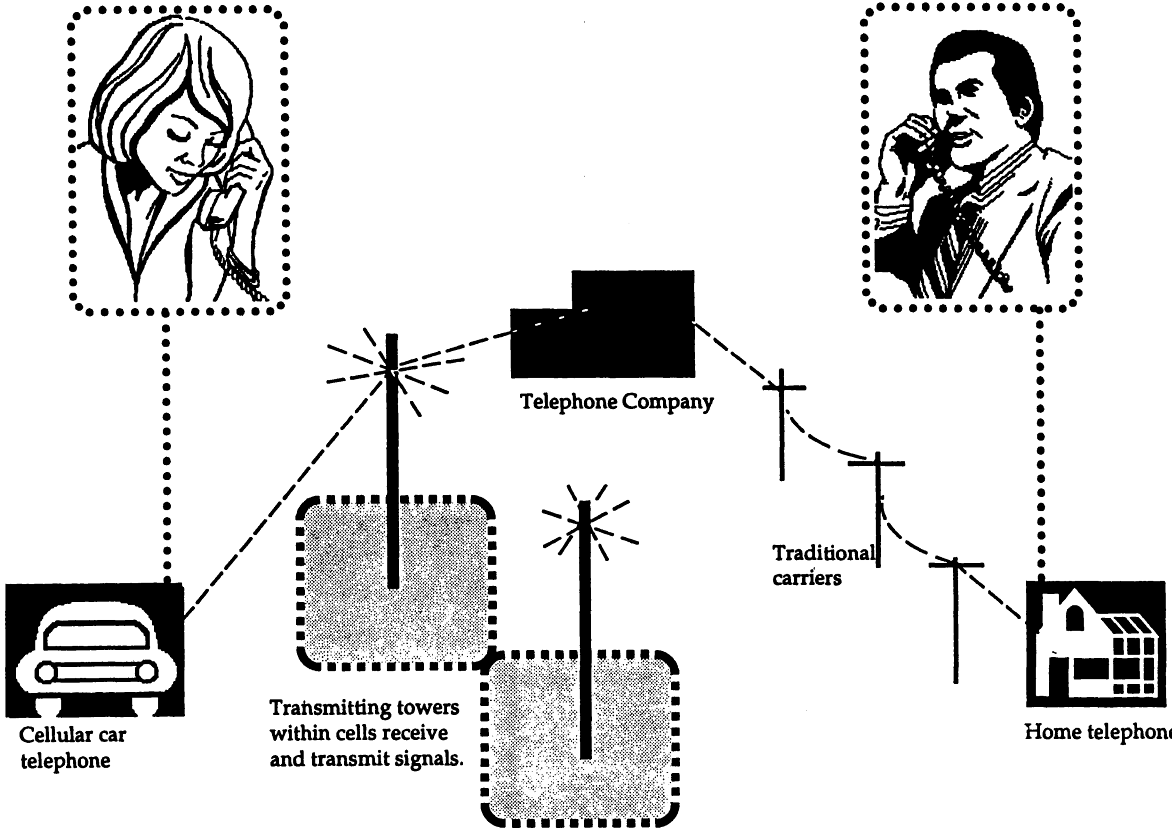

Figure 8-4: Cellular communication system.

and a user who is knowledgeable enough to access and make use of the process.

EVOLUTION OF COMMUNICATION TECHNOLOGY

Communication technologies are rapidly changing and becoming more multi-purpose in their ability to perform various applications. Today's fax machine can serve, not only as a fax, but also as a copier or telephone. Communication technology is now a composite of several independent innovations and developments that have occurred over the last 200 years. When combined, these have created rather powerful systems as shown in Figure 8–5.

There are many strands of history, inventions, and problems solved with technological applications that could be reviewed by students to see such interrelationships. It is interesting to have students explore these "connections" as a means of understanding how communication systems evolved. The development of television, for example, eventually led to lasers. The calculator led to the development of the computer. Photography and printing technology led to the electrostatic copier, then to facsimile capabilities, and eventually to scanning devices. Scanners have become unique input devices in our grocery stores as part of inventory control systems, and other versions are used to enter pictures and text into computer systems for publishing. When combined with X-ray and radio technologies, scanners are used to assist in medical diagnostics—communicating what's inside our bodies to our doctors.

Today's technologies have come to rely on sophisticated computer interfaces and microprocessors. When Alexander Graham Bell developed the telephone system, he had a simple desire to send signals over distance. When computer, facsimile, and telephone systems were combined with such sophisticated carriers as satellites and fiber optics, our telecommunications age became possible. Did Alexander Graham Bell realize that his development would lead to vast networking capabilities and access to information worldwide? It is unlikely that he would have anticipated the other parallel and interconnected developments that would converge in the 1980s and enable the information age to become a reality.

> A decade after cellular telephones first captured the hearts of the hurried and the well-to-do by letting them stay plugged in without being pinned down, the federal government is about to clear the

> airwaves for an expansion of wireless offerings more sophisticated than anything available today. (New York Times News Service, 1993, p. 1)

Recent developments and changes in the Federal Communications Commission regulations with regard to wireless networks will expand the access to and capabilities of personal communication devices and services by the mid-90's. According to Arthur D. Little, a consulting firm in Cambridge, Massachusetts, "personal communications services will generate 60 million customers in the United States by 2005" (New York Times News Service, 1993, p. 8). Little further stated the following:

> Using the digital electronics of computers, the new 'personal communications services' will be capable of sending data, images, and perhaps even video to an expanding family of nomadic computing devices palm-size computers, electronic notepads and what some people call mutant devices that combine the features of a telephone, computer, and pager. (p. 8)

COMMUNICATION TECHNOLOGY IN TECHNOLOGY EDUCATION

Communication Technology as a Content Organizer

Communication technology, one of four major curricular organizers (communication, construction, manufacturing, and transportation) for technology education today, is exciting and dynamic. It includes the study of concepts, processes, systems, devices, and end products associated with communication technologies. Communication technology encompasses not only audio and visual means of communication, but is anticipated to expand as new technologies, devices, and systems are developed and given practical applications. It continues to challenge teacher and student alike to reach levels of clarity (in sound), speed (in processing), volume (of data), accuracy (of information in visual form), and much more. Imaginations are able to be active as the classroom surrounds us in our daily living.

Creative problem solving is not only essential, but a logical means by which one can study communication systems. One only needs to think of some of the unlimited applications of communication technology in our lives and to structure the applications into categories. In this way, a wealth of information to share with students through exploratory and problem solving activities can become available.

Evolution of Communication Technology

Early Developments	Handset Type, Drawing & Drafting	Letterpress & Lithographic Printing	Optics, Telescopes, & Microscopes					Abacus, Spring & Jenny Loom	
1830's	Typesetting		Camera Obscura		Telegraph in Germany		Ohm's Law	Jacquard Loom & Babbage Analytical Engine	
1840's			Photographic Film		Telegraph in U.S. & Morse Code		Hertz Propagated Electrical Wave		
1850's		Offset Press				Phonautograph Sound Recording Device	Wheatstone Bridge (Resistance)		
1860's	Typewriter	Web-fed Rotary Press			Trans-Atlantic Telegraph		Boolean Algebra Electronic Logic Circuits & Maxwell's Principles of Electromagnetic Waves		
1870's		Automatic Folding Machines			Telephone (Bell) & Telephone Exchange	Phonograph & Edison's Vibrating Diaphragm Microphone			
1880's	Merganthaler Linotype		Gelatin Dry Film & Hand-held Camera	Scanning & Television Patent	Long Distance Telephone	Motion Picture Camera	Hertz Radio Wave Transmission/Reception		
1890's		Rotogravure Printing			Marconi Wireless Telegraphy	Radio	Preece Signal Sent Through Air		
1900's		Cylinder Offset Press			Wireless Transmission	Tape Recorder	Electron Tube, Edison Lightbulb, & Xrays		
1910's		Web Offset Printing	Color Photography				Audion Amplifier & Vacuum Tube		
1920's	Teletypewriters & Teletypesetters			"Talking" Movies, Electronic Scanning for TV & Iconoscope/Kinescope	Commercial Radio & Combination of Wireless Technology and Microphone				Goddard Space Rockets

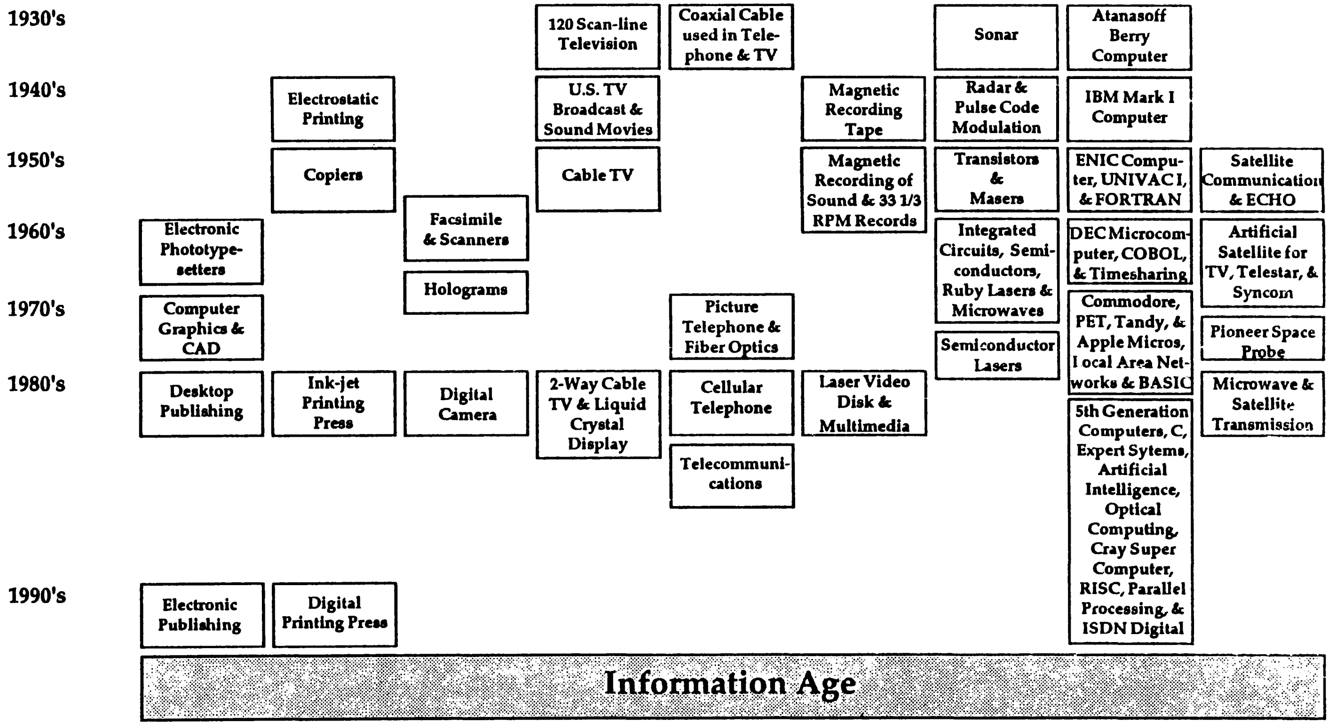

Figure 8-5: Evolution of communication technology. (Concept was adapted from Romano (1988) " Evolution of Electronic Printing and Publishing" in The S. Klein Computer Graphics Review *(pp. 16-17) and content was applied from "A Chronology of Major Events in the History of Communication Technology" in* Communication Technology *by Hendricks & Sterry, 1989, pp. 51-64.)*

As a content organizer, the communication technology curriculum can include the study of visual communication systems, such as computer aided design/drafting (CADD), electronic publishing, holography, and virtual reality. Audio communications systems can be explored, via broadcast radio, or combined with visual communication systems in the study of television, video, and the interplay of the computer as a controlling and mixing device for audio and video signals. Telecommunication systems, such as fiber optic, cellular, and microwave applications, form exciting units of study and extend our ability to explore beyond the classroom and into the universe. The linking of networks through computer integrated systems enables students to access data bases and to communicate with others globally. Other electronic imagery technologies and systems include laser applications (as input devices in inventory control systems, for example, or as input/output methods for visual data collection). These serve as topics that should be included in the curriculum to provide students with exposure to the breadth of systems that are applicable to communication technology as a content organizer. Teaching any one technology or system in isolation from other communication systems does not support the technology education curriculum intent. Teaching a variety of communication technologies through a systems approach fulfills the intent of technology education.

Historical Transitions

When manual arts and then industrial arts evolved as results of our early curriculum efforts, skills essential to the times were emphasized. Even those who were engaging in the course work as supplementary to other educational experiences (as an elective course) would find the instruction related to the basic tools and methods used for areas such as woodworking, drafting, or letterpress printing. A young person would follow specific steps for successful completion of a project, and parents would know that if their child was in grade 7 or 10, certain items would be made and brought home. Craftsmanship and repetition of the model (pattern or plan for each item) was expected. There was little room for creative effort.

Within the early curriculum drafting, printing, and subsequently photography and electronics were included. Students would engage in years of sequential learning within these subjects. In the late 1960s and early 1970s, I was enrolled in Drafting I, Drafting II, Drafting III, and Drafting IV to experience all one needed to know at the secondary level about mechanical drawing for machine parts and architectural plans. Likewise, Graphic Arts I-IV and Electronics I-IV would be offered in typical comprehensive high schools. Eventually, these three major subjects would be identified as falling within a cluster called communication. Graphic arts as a subject area

A Curriculum to Reflect Technology
William E. Warner

Communication Division:

Composition & Duplication	*Transmission & Reception*	*Interpretation*
Graphic Arts - Sound Recording	Mechanical-Electrical	Visual, Sound & Codes
Drawing, Sketching	Telegraphy	History
Drafting, Blueprinting	Telephone	Signal Flags
Letterpress	Radio (CW, MOD)	Lights
Photography	Teletype	Sound Devices
Intagliography	Facsimile	
Planography	Television	
Duplicating	Multi-Channel Methods	
Sound Recording	Radar	

Adapted from "A Progression of Technology in Industrial Arts Education" by Kenneth Phillips in *Technology Education: A Perspective on Implementation* (1985), Reston, VA: American Industrial Arts Association.

Figure 8-6: A curriculum to reflect technology.

underwent transitions in some state curriculums. It was broadened to graphic communication by some and visual communication by others. Even today, despite efforts to integrate the study of communication technology fully into technology education, some schools still offer drafting, graphic arts, and electronics as discrete courses, following the industrial arts curriculum model.

As early as 1947, William E. Warner of The Ohio State University promoted the inclusion of communication as a curriculum division in his presentation entitled "A Curriculum to Reflect Technology" (see Figure 8–6) at the first annual convention of the American Industrial Arts Association (Phillips, 1985). Warner's approach was to review socioeconomic data, including the census, to designate divisions that we could use in our curriculum. His efforts were an early attempt to reflect societal trends rather than tasks or jobs performed in industry. This approach would be consistent with the efforts throughout the 1980s and 1990s to remove the trade orientation and skill development activity and to employ an approach that would reflect systems and trends and how they impact on society.

It appears that the societal trends identified by Warner were adequate predictors of the 30 year period that followed. Societal data could be used today as a means of updating this model. It would be a very relevant means and a viable perspective from which to explore communication technology with students. Much of the change that has occurred in society has been due to the increase and improvement in communication methods. The greater the awareness between individuals, the faster information and technology is shared and applied to new developments. Communication methods reflect societal needs, and the drive for efficiency and innovation improve the technology and create new solutions to fill existing gaps in it.

The communication division of Warner's "A Curriculum to Reflect Technology" had three subsets. The first segment, composition and duplication, contained drafting, printing methods (graphic arts), and the means of replicating visual images and sounds or audio signals. The transmission and reception segment contained the mechanical-electrical means of communication. The third segment was the integration of codes and visual or audio signals. The means by which Warner developed this model and the logic of the model are very compatible with the logic employed today with our contemporary systems approach to technology education. Warner classified technologies by using similar systems and the means by which society employed the technologies—thus, applications of communication technologies.

The innovative programs of the 1960s were a series of attempts by curriculum developers and states to change from traditional manual and industrial arts to more contemporary approaches as a response to rapid changes in industry. As described in Cochran's (1970) publication entitled *Innovative Programs in Industrial Education*, seven major curriculum plans included communication as an organizer. The *World of Communication* materials by Hauenstein and Backmeyer (1974) were developed to teach about visual media. These materials did not survive the test of time in the American schools, at least not in industrial arts/education. What is interesting about the *World of Communication* materials is the inclusion of the communication model: Encoding-Transmitting-Receiving-Decoding-Storing-Retrieving. The similarly titled programs the *World of Construction* and the *World of Manufacturing*, developed through the Industrial Arts Curriculum Project (IACP) by Donald G. Lux and Willis E. Ray (1970, 1971), were popular at the junior high school level. Graphic arts and drafting had strong advocates in the schools, however, and as such they continued to be offered in much the same way as they had been for decades.

The real thrust for communication as a curriculum organizer within industrial arts/education came in the late 1970s and early 1980s when the Jackson's Mill Industrial Arts Curriculum Theory project group convened. (A more comprehensive description of the Jackson's Mill project may be found in Chapter 7.) The curriculum plan that was prepared by James A. Hales and James F. Snyder (1981) identified communication, construction, manufacturing, and transportation as the major systems used by humans to adapt to their environment. The systems were referred to as the human adaptive systems. A systems approach would have been perfect to prepare students for their future, given what we now know about the 1980s and the extensive development of communication systems that occurred throughout that decade. Teachers were more willing to change from woodworking and metalworking to manufacturing and construction, however, than to change from drafting, electronics, and graphic arts to the communication curriculum organizer. That is not to say that change didn't occur in some schools, but there wasn't a widespread curriculum change from the traditional subjects to the study of communication technology in an integrated way. Throughout the 1980s, teachers struggled with the gap between what they knew they needed to teach, what they knew how to teach (as a result of their past experiences), and what they had the resources to provide.

By the end of the 1980s and the beginning of the 1990s, teachers were ready to make the curriculum changes postulated a decade earlier. Computerization was widespread in business and industry and was finally affordable to most schools. Telecommunication methods were prevalent and resources to learn and teach about such systems became more readily available. Digital electronics was in place, lasers were widely used for varied applications, and fiber optics wasn't just being talked about as these systems were spanning the globe. It was evident that technologies were advancing in such a way that students needed to understand the interrelationships. Communication technology, as a course or courses within the technology education curriculum, was now perceived as more viable.

Updates in the tools and methods used to change courses, such as drafting to CAD, were seen by some as having moved to communication technology and technology education. That was not the case. One could not simply use computers in the classroom and claim that the curriculum was technology education, however, many schools did this. While it is positive to computerize instruction to reflect changes in business and industry, doing so did not mean that communication systems and methods were being learned by the student. To be consistent with technology education, the curriculum needed to provide problem solving, integrative experiences with a variety of communication technologies, and to employ a systems approach. Teaching CAD, electronic publishing, and digital electronics in isolation or discrete courses has not brought teaching about technology past the 1970s and 1980s approaches of industrial arts/education. Discrete courses are appropriate for vocational or pre-vocational programs, but for the general education of students a different emphasis and perspective are needed.

Documents of the profession throughout the entire second half of the 20th century chronicle the ongoing efforts that took place to include communication as a content organizer within the curriculum. The International Technology Education Association's 1985 *Standards for Technology Education*, Council on Technology Teacher Education annual yearbooks, state curriculum reports, scholarly journals, conference proceedings, and presentations by academicians at all levels depict the continued call for change.

STATUS OF COMMUNICATION TECHNOLOGY EDUCATION

Curriculum Activities Into the 1990s

As the curriculum began its transition from industrial arts to technology education, more happened than the inclusion of the Universal Systems Model as the structure for inquiry. The content organizer of communication technology needed to include additional systems and technologies to reflect better the changes that had occurred. As the 1990s were approaching, teachers began to increase the systems explored in the classroom to include optic systems (lasers and fiber optics), digital systems (integrating material from electronics, increasing computerization, adding the exploration of electronic mail, and utilizing teletext), and imaging systems. Many relied on modules or "canned" units provided by vendors, while others accessed a variety of technologies and integrated the study of these additional systems, using creative instructional methodologies. Many teachers found the modular approach to be a relief in the sense that they were able to add technologies that they knew little about, with the modules providing learning experiences rather simply. Some educators criticized this approach as not integrating systems into technology education with problem solving and group involvement by students. Nonetheless, changes in content started to become more evident. Some schools eliminated their shops and replaced them with modular laboratories, while others phased out the industrial approaches of the past and reorganized the learning environment to facilitate new instructional strategies.

An informal poll was conducted in the Fall of 1992 by this author. Technology teacher educators at major preservice institutions (40 institutions contacted with 26 returns, a 65% return rate) revealed that 22 states had included communication technology in the transition from industrial arts/education to technology education. Four reported that they had not done so. Most affected were the middle school, junior high, and high school levels. Three respondents indicated that the curriculum change was also occurring at the elementary level. When asked if the teacher preparation institutions were focusing on communication technology in their preservice education, 20 affirmative responses were indicated while four reported no, and two indicated that the curriculum somewhat included communication technology. It is heartening to see that teacher preparation is changing at the institutions that produce the greatest number of technology teachers for our profession. Accreditation by the National Council for Accreditation of Teacher Education (NCATE) and the need for teacher preparation programs to comply with the four curriculum organizers has prompted many schools to change emphases.

In looking at what the states are doing regarding classroom teachers in the public schools, there was a split in positive and negative sentiments. When asked to characterize the level of commitment or change to communication technology within their states: "marginal," "mediocre," and "passive" were selected just as frequently as "excited," "enthusiastic," and "committed." In the early 1990s there were still resistant and unconvinced teachers, while others embraced the dynamic changes of a new curriculum.

Communication Technology Curriculums

Each level of technology education requires a realistic assessment of what the educational goals are for students at that level. In selecting learning experiences, the teacher must recognize what students of various ages are capable of learning and the appropriate methodology to fit their experience and maturity. Recognition of the goals of technology education at each level is also essential. Most communication technology content will be suitable for the full range of educational levels, provided the teacher designs the learning experience, environment, and activity to fit the grade level.

The study of telecommunication systems is a good example. At the elementary level, students are learning to use the telephone at home. They answer the phone for their parents and they communicate with relatives. Activities that focus on how they, as people interact with the device and how the telephone system connects them to other people can be easily developed. Children explore how they would communicate with their relatives if the telephone were not available or look at future ways in which they might communicate in addition to or instead of the telephone. The elementary teacher can use the resources of technology education to enhance language and writing development through such activities.

The same activity extended to the middle school or junior high school level would include problem-solving situations. An example might be, "What happens to communication systems during a major storm, such as the Florida hurricanes?" A situation is described and the students receive the context of the problem. Model solutions can then be presented by teams or groups as a result of research and development.

At the secondary school level, students might examine the technologies included within a system in greater depth. The same telecommunication network of using the telephone system can be expanded to cellular systems and their impact on the community, on the sales and service sectors of business/industry, and on the increase of signals or noise in the air space. Fiber optic materials can be examined, the ability to send signals via light pulses explored, and problems/opportunities related to this technology studied. The focus then, at the secondary level, is greater in-depth exploration of the technologies that support the systems and the study of how they function both internally and externally.

Unique Approaches and Perspectives

Some technology education teachers have led the initiative to integrate technology education, and the study of communication technology specifically, with other disciplines and dimensions of the school curriculum. One such example is at Kenwood Academy, a secondary college preparatory magnet school located on Chicago's south side. Jimmie Jones, technology education teacher, prepared a proposal to the State of Illinois for a Higher Education Cooperation Act grant to improve Kenwood Academy's communication technology program. His project was funded for over $100,000.00, and he set up a curriculum where students enrolled in the communication technology courses would learn about various communication systems and then serve as the resource and content specialists for the integration of these systems into other classes.

An example of how this is working can be seen in the way the students study about radio broadcast systems. They learn the operation of an amateur ham radio, then take the ham radio capabilities to the foreign language program. Here, technology education students help other students who are learning foreign languages to connect, via radio, to ham radio operators in other countries. The foreign language students then practice their speaking and listening skills using the radio system and converse with native speakers as part of their foreign language instruction. Another example is the addition of video systems and television capabilities to the theater classes by establishing a filming studio. The school newspaper is the product of integrating English classes and the study of desktop publishing by the technology education students also. Jimmie Jones effectively infused the use of various technologies into courses where technology enables all students to learn more than they may have from the regular curriculum by simulating real applications of the technology.

State Approaches to Communication Technology in Technology Education

The *Industrial Technology Orientation Curriculum Guide (ITOCG)* (Illinois State Board of Education, 1989) provides for communication technology within the Illinois curriculum as one of four content organizers. The other three organizers are energy utilization technology, production technology, and transportation technology (p. 7). The main rationale for the inclusion of communication technology in the Illinois curriculum is that "we are living in an 'Information Age' and have become a society that seeks new and better ways to communicate" (p. 27).

The mission of the communication technology course in Illinois is "to orient students to the basic resources, technical process, industrial applications, and technological impacts in both graphic and electric means of transmitting and receiving information" (Illinois State Board of Education, 1989, p. 27). Units on drafting and design, graphic arts, telecommunication, and processing and communicating information with computers are included in the course (p. 28). In this regard the communication technology course is traditional in structure, emphasizing drafting, photography, and graphic arts content from industrial arts education. Information is communicated with computers and telecommunication (telephone, radio, television, fiber optics, and satellites), more contemporary additions that reflect a trend toward technology education.

A unit called "Introduction to Communication Technology" precedes the other units. This unit is based on suggested learning objectives provided in the ITOCG that emphasize the use of the Linear Model of Communication Technology (see Figure 8–2) described earlier in this chapter. Suggested learning experiences include an introduction to the communication model, introduction to a variety of graphic and electronic forms of communication technology, examination of how technology is used to solve communication problems, and the evolution of communication technology and how it shapes our lives. Unfortunately, this approach only comprises 1/6 of the course content and emphasis.

The "Drafting and Design" unit is traditional drafting with the addition of computer aided drafting (CAD). The "Photography" unit is also traditional photography content and methods. The "Graphic Arts" unit is steeped in traditional graphic arts processes like "typesetting, formatting, composing, illustrating, stripping, photographing, registering, duplicating, binding, and finishing" (Illinois State Board of Education, 1989, p. 40), without attention to processes that have been eliminated or changed by advances in technology. Of 18 objectives provided for this unit, only one includes contemporary technology (electronic publishing technology and its impact on employment patterns, printing costs, etc.). Many Illinois schools have increased the amount of electronic imaging taught within this portion of the course.

The "Processing and Communicating Information with Computers" unit focuses heavily on hardware and software terminology and utilization, historical development of the computer, and computer programming. It is likely that an instructor teaching this unit today would emphasize using existing software packages versus programming a computer. It is in this unit that we see the Universal Systems Model (see Figure 8–1) appear and become a part of the objectives of the unit.

The "Telecommunication Technology" unit includes the study of signals (electromagnetic waves) such as radio, telephone, and television. Problem solving is also included in the learning objectives for this unit. The evaluation of the impacts of telecommunication technologies is presented. This is the most contemporary unit and that which is most closely linked to a technology education approach to learning content.

The Commonwealth of Virginia *Technology Education Program of Studies* (Commonwealth of Virginia Department of Education, 1986) indicates the following, regarding technology education courses at the middle school or junior high school level:

> [They are] exploratory in nature, designed to promote student investigation and examination of broad content areas such as communication, construction, manufacturing, and transportation. Technology education is recommended for all students at this level regardless of career goals or education plans. Courses should be designed to lead into programs at senior high school and post secondary levels. (p. 9)

At the high school level, 300 hours of instruction are offered with two course options. "Instruction enables students to develop competencies in the areas of communication and media, resulting in occupational readiness useful to the future craftsperson, technician, technologist, or consumer" (Commonwealth of Virginia Department of Education, 1986, p. 25). One course is called Communication Technology and the other is Graphic Communications I. Communication Technology is designed for grades 9, 10, or 11 while Graphic Communications I is to be offered at grades 10, 11, or 12. The course description for Communication Technology indicates that the following occurs:

> Students study visual and telecommunication systems, processes, and organizations. Learning experiences include the study of numerous technical developments such as radio, television, offset printing, and

> photography. Basic technical skills are developed in drafting, graphics, photography, and telecommunications. (p. 27)

In this way the Virginia curriculum materials are similar to that of Illinois. Course goals include, but are not limited to, experiences and activities in (a) the basic reproduction processes; (b) the interrelationship of drafting, graphic arts photography, and telecommunications; (c) drawing, industrial design, technology problems of electronic design and servicing; and (d) regulations in the installation of electrical components. Despite the course title, most of the content and objectives do not focus on a systems approach to the study of communication technology. The exception to this is during the introductory content of the class, entitled "1. Introducing Communication Systems" (Commonwealth of Virginia Department of Education, 1986, p. 28), and in the telecommunication portion of the course.

The "Graphic Communications" course follows the "Communication Technology" course. This course deals with "printed images in such as newspapers, books, printed T-shirts, signs, photographs, wallpaper, or stationery" (Commonwealth of Virginia Department of Education, 1986, p. 29). Graphic arts equipment is used for students to "make visual projects with different materials. Students design, plan, and reproduce products similar to the graphic arts industry" (p. 29). The content and goals of this course reflect industrial arts/education. In addition to the two courses presented within Communication Technology, Virginia offers three courses in Drawing/Design and two courses in Electricity/Electronics.

The Utah State Office of Vocational Education, in conjunction with Utah State University (no date), prepared a senior high school course for technology education called Communications Systems Technology. Utah developed their course to cover an 18-week time period and it was "designed to introduce students to the many ways we communicate in our society" (p. 1). One unit within this course is "Introduction to Communication." It includes the following: elements of communication, types of communication systems, communication technologies (design and drafting, computers, photography, graphic communication, and telecommunication), evolution of communication, and impacts. The Universal Systems Model is utilized in this course to help explain the communication process. The communication technologies selected for study are once again fairly traditional components from past curriculum efforts. What is stronger in this planned course is the emphasis on the impacts of communication technology (social/cultural, environmental, technological, and economic).

The North Carolina State *Vocational Education Program of Studies* (North Carolina Department of Public Instruction, 1987, p. 52) provides for K-6 Integrated Technology, Grade 7 Exploring Technology, and Grade 8 Contemporary Technology. In Grades 9–10 the students can enroll in one of the four content organizers (for example, Communication Systems). At the Grade 9–10 level the Communication Systems course is described in the following manner:

> A general introduction to technical communications systems and processes within the communications industry is present. The course identifies visual, graphic, and other forms of communication. Emphasis is placed on the interrelationship between management and production elements. Mathematics and scientific principles related to communications skills will be included. Personal abilities, special interests, and career possibilities in communications systems are identified. (p. 53)

Grades 11–12 have three courses related to communication systems. They are Graphic Communications Systems, Electronic Communications Systems, and Media Communications Systems. At Grade 12, students may also enroll in Technology Research and Development or Industrial Enterprise. As an example of these upper level courses, the Electronic Communications Systems includes the following:

> General introduction to contemporary communications technology including telecommunications, hard-wired, computer, light, and acoustic systems. Specific electronic communications products shown and explained, an overview is given of the nature of the electronic communications industry and its present and future impact on the economy and society. (North Carolina Department of Public Instruction, 1987, p. 53)

The extent to which each of these courses is offered at any given secondary school program is dependent upon the number of teachers employed by the school. The state plan provides guidelines as to which courses are to be offered, given one to three teachers at the secondary level. If a school has only one technology teacher, it is suggested that Communication Systems be taught at the 10th grade level and Media Communications be taught at the 12th grade level. No other communication related courses are recommended. For larger school programs, all courses are to be offered.

In New Hampshire, the State of New Hampshire Department of Education, Bureau of Vocational-Technology Education *Technology Education Curriculum Guide* (1992), provided five content organizers for their curriculum. They included Communication Technology, Construction Technology, Manufacturing Technology, Energy, Power, and Transportation Technology, and Biotechnology (p. 8). In the New Hampshire *Technology Education Curriculum Guide,* Communication Technology is described as follows:

> Communication Technology is the accurate transfer of information from a sender to a receiver. Communication courses introduce students to classifications, terminology, technical systems and processes used by industry and provide sample activities that support those understandings. More than half of the American population is involved in the generation, manipulation, storage, transmission and marketing of information. (p. 8)

Suggested elementary level activities for the study of communication include technical system collage (Grade 6), logo design (Grade 6), satellite dish (Grades 5–6), and safety poster contest (Grades 5–6). Of the 24 suggested activities at the elementary level (which included grades 1–6), only the four listed were provided for the study of communication. By comparison, there were 16 activities that fit the content organizer of construction and 10 activities that also fit the content organizer of manufacturing. While many of the suggested activities were contemporary and interdisciplinary, there were several which were a curiosity to the author. One such example, listed as a manufacturing systems activity, was the making of a printer's hat. While the folding of newsprint could be considered geometry and a manipulative task, the curriculum indicates that "reading" is the content that is integrated in this activity. Another curiosity is the model satellite activity that was listed as a construction activity. Why is this not a communication activity, with students studying how a satellite is an important component in our daily television and telephone utilization?

What these examples point to are curriculum plans that have moved forward in the use of the four (or five) content organizers, but have yet to examine fully how activities can support a systems approach through contemporary and future oriented activities. Activities, historical or cultural in nature, can be integrated with the study of technology. One such example from the New Hampshire curriculum is the manufacturing of the African Mankala Game.

The New Hampshire Curriculum Plan for technology education at the middle school and high school levels emphasizes Verbal/Nonverbal Communication Technology, Graphic Communication Technology, Electronic Communication Technology, and the Trends in Communication Technology (State of New Hampshire Department of Education, 1992, pp. 16, 28). What is perhaps the most interesting component of the New Hampshire curriculum is the student performance outcomes (State of New Hampshire Department of Education, 1992, pp. 15, 26–27). In these outcomes, two additional definitions of communication technology are found: (a) "the application of technological systems that efficiently utilize resources to transmit information" (p. 15) and (b) "the study of the technical information systems, careers and their requirements through constructive activities involving safe and proper involvement in processes relating to message ideation, composition, transmission, reception, interpretation and reaction" (p. 26). The former definition accompanies student performance objectives for the elementary level, while the latter definition accompanies the secondary level student performance objectives.

The Ohio curriculum materials provided for in the *Technology Systems Handbook* (Savage, 1990) include descriptions of the "Technology Domain" and include the following definitions/descriptions for communication technology:

> The Communication Technology System—The spectrum of human technological activity within the environment addresses the historical development of communication systems, their current applications, and consideration for future developments enhancing the communication process. (p. 56)
>
> Communication—Studies the human ability to relate experience and the technological product and process which have contributed to, or expanded, those abilities. Studies which focus on the understanding and utilization of symbol systems are ideal for the infusion of related technology topics. (p. 57)

Little is done in communication technology at the middle school or junior high school level based on the *Technology Systems Handbook*. At the 7th grade, an activity called "Communicating a Message" and at the 8th grade "Computer Generated Media" are listed. The high school level includes a one semester course entitled: Communication Systems. According to the course description, which follows:

> The course provides an introduction to technical communication systems and processes. Students will participate in activities based upon the concepts of: printing, photography, drafting, computers, audio, video, and telecommunications. As a culmination of these experiences, the student will create, implement, and evaluate a network to solve a communication problem. (Savage, 1990, p. 155)

Course content provided for in this curriculum guide is enhanced by suggested learning experiences. These are contemporary examples and provide teachers with good ideas for implementation. In addition to the Communication Systems course, a one semester Communication Networks course and a one semester Computer Applications in Technology course are included in the Ohio curriculum. The Communication Networks course "synthesizes the application of technology to the solution of communication problems" (Savage, 1990, p. 161). A problem-solving methodology is built into the design of the course. "Creative problem solving and decision-making skills are developed and basic communication processes are learned" (p. 161). According to the course description, "the majority of the class time is devoted to message design and the technological practices necessary for applications of the communication networks" (p. 161).

The Computer Application in Technology course targets the development of computer competence "through select activities covering the interface of computer hardware and the application of computer software" (Savage, 1990, p. 165). An introduction to computer theory is included. Students examine communication applications of the computer as well as manufacturing applications, service industries and business applications, transportation applications, construction applications, and bio-related applications. This course integrates each content organizer for technology education by examining the computer applications that relate to those areas. At the secondary level, the Ohio curriculum model is rather strong and well defined for communication technology in technology education.

The New York State curriculum *Technology Education: Introduction to Technology (Grades 7 & 8)* (University of the State of New York, 1986), calls the program for grades 7–8 Information/Communications Technology and includes information processing, photography, and graphic and electronic communication. At grades 9–12, the program is called Communications. It includes as activities the analysis of a television commercial with scripting and storyboarding, paste-up, public relations campaign, video production, sound/slide, computer imaging, telecommunications, and computer applications.

Pennsylvania's *Technology Education in Pennsylvania Program Guide K–12* (The Technology Education Association of Pennsylvania & The Pennsylvania Department of Education, 1988) provides for curriculum recommendations for Technology Education under Chapter 5 of the State Board of Education Curriculum Regulations and Chapter 6 of the Vocational Education Regulations. At the elementary grades (K–5 or 6), "No required planned courses but Technology Education instruction should be integrated into the curriculum to meet the 12 Goals of Quality Education" (p. 16). At the secondary grades (6 or 7–12) there is a required planned course for all students. This course is a minimum of 120 hours of instruction in technology education. This course "should encompass content areas in: Communications, Power/Transportation and Manufacturing/Construction" and "should be taught in the middle or junior high school grades" (p. 16). Additional "Offered Courses for All Students" must be provided as electives each year for students in grades 7–12. "At least one technology education course should be offered representing each of the three content areas: Communications, Power/Transportation and Manufacturing/Construction" (p. 16).

In Pennsylvania, technology education provides appropriate graduation credit under arts and humanities for up to two units of credit. Technology education provides appropriate graduation credit under additional courses for up to five units of credit (one unit of credit equals 120 hours). Pittsburgh Middle School (as an example of the Pennsylvania curriculum) offers 11 modules relating to communication technology from the 24 modules in their Explorations in Technology course. Topics include electricity, electronics, drafting, research and development, computers, printing, radio/communications, and television.

In the Oklahoma State Department of Vocational and Technical Education's *Technology Education: A Description and Listing of Programs in Oklahoma* (1987–88) the curriculum materials for grades 6–10 describe Exploring Communication Technology as an appropriate course. It includes an introduction to communication, followed by designing messages, producing messages, evaluating messages, and discussing career and leadership opportunities. Technology Education I, II, and II are offered for grades 6–10.

> The materials in this ever-changing field is [*sic*] designed to provide students with the opportunity to explore the fundamentals of message design, production, and transmission using audio, visual, and audio-visual methods. Included in the activities are career exploration in CAD, other types of drafting, graphic arts, photography, electronic communications, and computer utilization. (Oklahoma State Department of Vocational and Technical Education, 1987–88, p. 3)

The 1987 *Report of the Commission on Technology Education for the State of New Jersey* (Commission on Technology Education for the State of New Jersey) included for grades 10–12 or curriculum levels III & IV Applying Technology. This encompassed telecommunication, electronic communication, and graphic communication courses. Grades 9–12 could take course work focused toward "studying technology," which included information processing.

Three courses from the Michigan *High School Curriculum Guide (Kalamazoo High School)* (Michigan Department of Education, 1988) are examples of secondary level endeavors. The first is a one-semester course entitled Information Technology Systems. "This course provides an introduction to technical information systems and processes. Students will

Information Technology Systems

Introduction to Information Technology Systems

Communications
- Graphic Design
- Commercial Design
- Publishing
- Cartooning
- Telecommunications
- Satellite

Manufacturing
- Computer Integrated
- CIM (Computer Integrated Manufacturing)
- Robotics
- CAD (Computer Aided Design)
- Computer Aided Drafting

Service Industry/Business
- Electronic Mail
- Banking, i.e. Credit, Transactions (Checking and Deposits)
- Stock/Commodities Market
- Accounting, Word Processing, Payroll
- Code Scanning (Bar/Magnetic)
- Demographic Studies

Bio-Related
- Athletics
- Medicine (Diagnostic and Prescriptive)
- Diet/Food Selection
- Agriculture
- Ergonomics (Comfort Design)
- Electronic Vision

Transportation
- Vehicle Control (Braking, Drive Train, Environment, Lighting, Navigation)
- Traffic Control
- Rocket Design
- Elevator Control

Construction
- Estimating, Materials, Costs, etc.
- Structural Analysis
- Money Needs
- Environment
- Security

Figure 8-7: Content for information technology systems.

participate in activities where they will learn the concepts of: printing, photography, drafting, computers, audio, video, and telecommunications" (p. 1). What is much more interesting is the content outline presented for this course (see Figure 8–7). Note that information technology systems are studied across the various content organizers for technology education.

The second course is called Computer Application in Technology. Computer hardware and software application enables students to develop computer confidence. The content of this course is fairly typical of most secondary level computer courses, but there is an emphasis on problem solving and decision making. The Communication Networks course is also a very interesting one. "In this course students define the message, identify the audience, select the medium, produce the communication product, present the solution, and evaluate the effectiveness of the product" (Michigan Department of Education, 1988, p. 1). According to the material provided, the majority of time in this class is devoted to message design and technological practices for production of the communication network. The Linear Model of Communication is utilized within this course. Information systems, communication design, application of information technology theory, and networks are key units. The application of information technology theory covers (a) drafting (visualization, sketching, creative problem solving, elements and principles of design, technical drawing, and CAD systems); (b) photography (photographic fundamentals and exposure systems); (c) printing (image design, image assembly, image conversion, image carrier preparation, and image transfer); and (d) electronics (telecommunications, computers, audio/video).

While the review and discussion of state curriculum guides/materials is not extensive nor all-inclusive, a variety of approaches are offered to highlight the current status of communication technology efforts. Some traditional strands still show. Some are additions that reflect contemporary communication systems, and some are innovative approaches that are preparing for the future. It is anticipated that the 1990s will be a time of great change in classroom approaches and activities for the delivery of communication technology content. The last half of this decade and century must serve as a context and impetus for great change in state curriculum plans for technology education. Those classroom teachers and technology teacher educators who have made great strides in philosophical and practical implementation of technology education must drive overall curriculum change in their states. Because the development of state-wide curriculum plans is often slow and arduous, it becomes evident (if not obvious) that the classroom teachers are often the more future oriented, creative, imaginative, resourceful, and integrative supporters in their efforts.

COMMUNICATION TECHNOLOGY IN TECHNOLOGY EDUCATION: FUTURE DIRECTIONS AND CURRICULAR IMPACTS

The rapid technological advances in our global society, the importance of new and vast levels of knowledge to our everyday lives, as well as the ways in which communication devices and systems enable the information age to expand, cannot and must not be overlooked by curriculum planners, classroom teachers, and teacher educators. We, in technology education, must use and apply communication systems and thus provide for students in communication technology curriculum and instruction that relate to today and prepare students to face continuing changes in the future. We must force ourselves to depart from past practices of compartmentalizing content into discrete subjects (CAD, electronics, photography, graphic arts, etc.) and open the learning process to unique approaches for the study of communication technology and systems. We must look at the full range of content that is essential for the understanding of communication technology and we must anticipate what knowledge and skills our students will require to be successful in the next century.

What communication technologies and systems will our students today encounter and use in their future education or training, employment, and daily lives? What problem-solving processes and techniques must students explore and experience at the elementary, middle school or junior high, secondary, and post-secondary levels that will facilitate their interaction with and application of communication technologies and systems? As technology educators we must be able to include the answers to these questions in our daily instruction by providing students with a variety of quality learning experiences.

We must create a new learning environment and use multiple teaching strategies to be able to "change with the times" and not teach from the past. By employing instructional strategies and methods such as systems approaches, integrated and interdisciplinary activities, creative problem-solving techniques, multicultural contexts, and research and development models, the student and teacher together explore new communication technologies. They also learn about new advances as developed and applied in business, industry, government, and education.

Professional Responsibilities

Preservice activities and teacher preparation programs must emphasize how to develop and change curriculum, as well as teaching and learning strategies that employ a variety of instructional methods. They must create and maintain a dynamic learning environment and be accountable for learning through student assessment. Technology teachers must be prepared to present local schools and communities with models for the future. Without these tools, the technology teacher will have difficulty succeeding.

The preparation of technology teachers must include communication technology as a content organizer in a setting that is appropriate to the study of communication technologies and systems. Future teachers cannot be expected to learn this content from discrete courses designed for industrial technology majors (CAD, printing technology, and electronics, for example). This situation would be no better than the secondary and post-secondary programs of the past. Preservice education must support learning about the technologies and systems of each content organizer with opportunities to experience the variety of instructional strategies inherent in technology education today. New teachers model what they have learned and how they have learned. Teacher education programs must therefore create "model" learning environments that provide for the preservice teacher a quality experience to emulate in their future teaching assignment.

The NCATE accreditation requirements for technology education monitored through the Council on Technology Teacher Education and the International Technology Education Association must include provisions to examine these issues. We must assure that our graduates have truly experienced a technology teacher education program (versus programs where course titles have changed but content and methods have not). Professional standards and rigor insure that the quality of our teachers is intact, and that students at all levels receive a quality technology education.

Inservice activities and the continuing education of existing technology teachers is a constant need. The daily demands on classroom teachers leave little time for preparation and planning, let alone personal professional updates or technology enhancement. An organized effort at the local, regional, and national levels is required to enable teachers to implement technology education and maintain teaching competencies (curriculum development, instructional methods, student assessment, and technological knowledge/ability).

Technology teacher education and the responsibilities linked closely with preparing future teachers for the public schools can serve as a catalyst for ongoing inservice activities. Involving classroom teachers in the teacher preparation program beyond that of acting as cooperating teachers for practicum experiences is essential. Inviting classroom teachers to spend time on campus with students, to present activities such as those taught in their own programs, and to learn new technologies from preservice students are some options. Engaging preservice teachers in the planning and delivery of inservice programs channels their talents and abilities toward helping others in the profession.

Demands on technology teacher educators are great with regard to the triad of teaching, research, and service. They are required to be, and should be, exemplary teachers. Research and scholarship are expected to support the role and mission of the university, but service, which formerly comprised the largest portion of efforts outside the classroom, does not get the support from internal university evaluation systems that it once did. Thus, technology teacher educators may not conduct the same quantity of inservice activities that were delivered to classroom teachers in the past.

The responsibility for keeping inservice programs viable rests with the local/regional school district and state departments of education. District administration must create support for teachers to grow professionally, whether it be by attaining leadership roles in professional organizations, by sabbatical leaves, by attending conferences and workshops/seminars, by internships in business and industry, or by providing qualified substitute teachers so that the classroom teacher can visit other programs recognized for outstanding curriculum and instruction. Teachers need to see other educators in action with children and young adults. Isolating teachers for inservice programs in front of computers can work to teach software programs, but it doesn't demonstrate successful classroom techniques and approaches to new technologies. Districts can use lead instructors as models and mentors, provided adequate time and resources are also allocated to help such programs be successful endeavors.

The state departments of education must provide inservice programs to support state curriculum efforts. Funding for individuals and teams of teachers to try unique professional development plans must be implemented. State-wide efforts to have each teacher plan and prepare for ongoing education, training, and learning opportunities cannot be delayed. Teacher certification in the future has to be linked to lifelong training to insure that educators make the effort to learn about new techniques of teaching and new technologies. State supervisors responsible for technology education must be urged to reexamine their state curriculum plans, to develop new strategies for helping to relieve the pressures that bear on overburdened teachers and undermotivated teachers (those who say "I'll retire before I . . . "), and to provide model inservice programs.

Professional association responsibilities are manifold. Some teachers join local, state, and national professional associations for the publications, while others seek the professional support and activity gained through attending conferences and workshops. Though many teachers view professional association membership as essential to conducting a successful career, others simply opt out. Professional associations must bring to those who are involved the opportunities and experiences that will help them join in and, hopefully, update their technology education programs. That may mean going to the teacher where the teacher is. Many classroom teachers are not given time off or financial support to attend a state or national conference. Local and regional conferences with action oriented inservice activities are best. One-day and two-day presession (before school opens) or post-session options delivered as close as possible to the teacher's domain may offer one solution.

Inservice programs must become as dynamic as the technologies we are presented with to teach. To challenge teachers today, inservice activities that are unique, such as multimedia instructional technologies, team planning and group learning exercises, model curricula for teachers to modify to fit their circumstances, field trips to business/industry to observe technological development or applications of systems, and much more are needed. Ask teachers what they are lacking and surely they'll respond with the word help followed by resources, new equipment, and training in new technologies.

Linking education with business/industry sources assists teachers in keeping contact with changes and with development in communication technology and systems. Teachers may elect to serve as interns in local businesses or industries during summer months. Technical resources abound in business and industry through employees as guest speakers, literature/materials used to train in industry, videos or promotional materials for corporations, samples of products, donations of equipment and supplies, field trips and shadowing experiences for students, and a host of other possibilities.

Business and industry advisory committees aren't just for vocational education programs. Such partnerships bring corporate leaders to the classroom and create advocates in the community. Good advisory committees help teachers maintain facilities and access community resources. By planning meaningful meetings with advisors, the teacher gains the respect of corporate leaders. Educators should ask major companies within their regions to "Adopt a School" or better yet "Adopt a Technology Education Program." They should select companies that are communication technology intensive, such as vendors of communication equipment, advanced users of communication systems, and communication corporations (e.g., the telephone or cable TV company).

Establishing dynamic facilities capable of changing as technologies change and utilizing a multitude of medias for instruction requires planning, and both internal and external support. Using business and corporate contacts is paramount. Demonstrating the societal need to understand communication technologies and systems to school administration is essential at all levels of technology education. Flexibility and dynamic growth must be guiding principles for the planning and constant modification of the learning environment. A scenario where students can learn through group activities, team research and development, simulations and models is an exciting learning environment for youth. Not only will they want to learn but they'll want to come back to learn more. On the other hand, children put into compartments (modules) or expected to do the same thing in the same way (drafting exercises) lose creativity. The inventiveness of teachers today provides us with students able to explore and learn tomorrow.

Access to rapidly changing technologies isn't always within the school budget. A plan to implement new technologies by phasing them in over time and gradually replacing obsolete units of instruction or activities may help. Beyond these resources of the laboratory budget there really are additional sources, because money isn't always needed to gain the equipment, supplies, and materials necessary to teach about communication technology and systems. The technique that every teacher has to learn is simply to ask for help. People rarely say no to requests that involve students learning about what they have to offer. There are examples in our daily world like the grocery store scanner and inventory management system, local telephone and cellular service providers, cable television or public broadcasting stations, newspaper or printing companies, radio stations, amateur radio clubs or remote control aircraft group, fishing boats with Loran or radar systems, police vehicles with radar and emergency radio systems, hospitals with imaging technologies, and even more options available to the resourceful teacher. Some equipment can be borrowed while other devices can be rented (such as video machines).

Gaining sponsorship/donations and financial support does take time and classroom teachers as well as teacher educators often have precious little left over, if any, at the end of the day. Efforts made to secure external funding or support from business/industry, however, is an investment in the future. Available through the International Technology Education Association is the *Guide to Funding for Technology Education* (Liedtke & Loepp, 1992). This guide, along with other reference books, helps technology educators increase their chances of gaining funds or equipment from corporate and private sources. Local libraries, reference foundation directories, and grant guides that are also valuable resources. The United States government has several programs designed to provide advanced technologies (devices including oscilloscopes and similar instrumentation) to school programs. Clearing houses and centers help to link schools with industry donations of equipment and supplies.

SUMMARY

Communication technology in technology education is an essential ingredient in the education of all children today. It is impossible to ignore the importance and dramatic impacts that the information age is having upon our lives. As we enter the next century, we must take a quantum leap forward in the way classroom activities convey content to youth. Minds-on activities are as essential as hands-on activities in linking the study of communication technology to contemporary life. The responsibility belongs to all the people in technology education, and there is no better time than the present to act on what we have to offer children.

A comprehensive understanding of communication technologies through the systems approach will prepare students to problem solve with new technologies as they are introduced in the future. As children become increasingly interactive with communication technologies, their basic level of awareness and understanding will become common knowledge. The sophistication of advanced technologies will be the challenge of the future. Determining appropriate classroom activities and learning experiences to explain and experience the multifaceted integrated systems on the horizon will be quite a challenge.

The impacts that advancing technologies will have on society and the environment must be included in the study of communication technology. Awareness and concern for these important determinants of our lives and the changes that occur in our social institutions become important topics for instruction. Changing communication technology creates new opportunities for people and it also creates new problems for them. Mesthene (1986) stated the following:

> Technology is seen as the motor of all progress, as holding the solution to most of our social problems, as helping to liberate the individual from the clutches of a complex and highly organized society, and as the source of permanent prosperity; in short, as the promise of utopia in our time. (p. 72)

Asimov's predictions in 1989 of the techno-child became a reality in the 1990s and the classroom became the place to extend their curiosities and bring technologically able students to new levels of learning. Our exploration as technology educators into the next century will be a wondrous adventure filled with exciting and dynamic options for both the teacher and the student.

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CHAPTER 9

Manufacturing Technology Education

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Manufacturing has evolved over the past few years as the most developed of the four curriculum clusters originally proposed in the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, n.d.) document. The study of manufacturing technologies today is aided by a wealth of textbooks, media, and educational materials that are available commercially to classroom teachers. Organized manufacturing program experiences, especially the designing of consumer products and the operating of production lines, are found from the kindergarten to graduate school levels. These purposeful learning activities help students to understand the many facets of manufacturing that include the following: (a) how value is added to raw materials, (b) how industrial inputs become finished goods, (c) how facilities are designed for the efficient processing of materials and components, and (d) how enterprises are organized and managed. Instruction in manufacturing most often takes place in action-based technology laboratories where daily learning can be fun, interesting, and relevant to the students' understanding of the production sector of our society.

Manufacturing involves much more than the technical acts of machining, assembling, and packaging. A manufacturing system's inputs include money, labor, energy, and knowledge, with each requiring the attention of management and employees. Product and system design activities are also important, as is the organization and management of a manufacturing system. Processing by custom, intermittent, or continuous means results in both desired goods and undesirable by-products. The useful outputs, whether classified as durable or non-durable goods, must be evaluated for their impact on the environment and in the marketplace.

Classroom and laboratory experiences in a manufacturing program contribute to the students' knowledge of our technological world. Grayson and O'Dell (1988) insist that "an effective citizen or employee needs both" (p. 272) good cognitive skills (e.g., thinking, reasoning, content, etc.) and affective skills (e.g., enthusiasm, flexibility, interpersonal skills, etc.). Designing, building, testing, and analyzing products and systems help students succeed in a production-based economy. The hands-on nature of manufacturing education supports the goals of modern society.

Success in manufacturing is the result of the efforts, insight, and motivation of both management and employees. Manufacturers must formulate strategies that allow them to bring new and better products to the marketplace faster and more efficiently than their competitors. Corporate goals are developed to direct short and long term projects, but are continually altered to match market trends, economic conditions, and governmental regulations. Similarly, manufacturing educators are constantly challenged to maintain a current knowledge of production techniques, while enhancing their instructional strategies to match student needs and desires. The challenge involves many of the same strategic actions that are used by Fortune 500 companies. Teachers must be willing to update subject matter and facilities while responding to emerging practices of modern enterprises.

MANUFACTURING TECHNOLOGY

It is impossible to ignore the significance of manufacturing and its associated technologies. This yearbook, which was printed in a factory called a publishing house, is a prime example of a manufactured product. In addition, clothes, cereal, vehicles that provide daily transportation, and the chair on which one sits are other examples of manufactured products. On a larger scale, the quality of life in one's community and region is based on the economic success of area manufacturers and the wealth they may disperse to local residents through the creation of jobs. The use and disposal of manufactured goods also influence one's neighborhood.

One commonly held view of the history of the industrialized world often includes a familiar scenario where each nation's agricultural age is replaced by an industrial era and, in more recent times, the industrial era is then replaced by an information society. Actually, this scenario is completely false. In the western world, for example, agricultural production has never been replaced by anything. Agriculture has simply been automated to a point where less labor is required to achieve greater output. Cohen and Zysman (1987) remind us that "agriculture has by no means become an activity of the past" (p. 6), rather, it has become among the most productive of all human ventures. The natures of agriculture and manufacturing have changed significantly, but both remain vital to the economic success of a nation.

Modern manufacturing has followed a path similar to agriculture, resulting in higher productivity while achieving outstanding levels of value and quality. In the coming decades, it will become vitally important that a nation's industrial base not totally surrender to service-based industries. The current production systems, with statistical quality control techniques, participatory management, and "just-in-time" inventory systems, are a model of efficiency. World class manufacturing is practiced around the globe in automated factories, despite differences in cultures, religions, and working conditions. Yet, many citizens believe it doesn't matter if factories continue to shut down or move across national borders, as long as a service economy replaces lost manufacturing employment. In addition, they do not understand the importance of studying the organization and operation of manufacturing systems.

The international strength and influence of a country are linked to its industrial base. As a national policy, abandoning the manufacture of goods leaves only a highly automated agricultural sector and a largely service-based economy. Unfortunately, the service sector exists to support the activities associated with adding value to material resources. Without manufacturing, there is little need for high tech research parks, product distribution networks, advertising agencies, sales representatives, and data processing centers. A loss of manufacturing results in a reduced competitive advantage for a community, region, or nation. It is vital, therefore, that citizens understand the productive activities in society and the technologies specifically associated with adding value to material resources. Production technology, as a human activity, includes agricultural production, mining, construction, and harvesting, but the major area is manufacturing.

Wright (1990) notes that manufacturing technology "includes systems that transform materials into products in a central location" (p. 25). Manufacturing activities are often viewed using a systems approach, in an attempt to identify and study the inputs, processes, outputs, and impacts unique to manufacturing (Colelli, n.d.; Lauda & McCrory, 1986; Wright & Shackelford, 1990; Savage & Sterry, 1990). Whether on a personal or industrial scale, manufacturing involves converting raw materials into valuable products. Once the products are designed to fulfill a human need, the following typical sequence occurs:

1. Obtain raw materials by harvesting, mining, extracting, etc.;
2. Produce standard stock using primary processing techniques;

3. Change stock into industrial materials through secondary processes;
4. Fabricate and assemble the components into final products;
5. Package and distribute the products.

Naturally, the number and complexity of these steps will vary according to the material(s) used and the size of the product.

The development of industrial and consumer goods is directly linked to a technological method that can be described with a model of the problem-solving process (Savage & Sterry, 1990). Manufactured goods are designed to fulfill a specific need or desire. Industrial research and development activities result in an approved product design specified with drawings, bills of materials, and related data sources. Knowledge of the problem-solving process is important to understanding the field of manufacturing technology.

In a similar manner, manufacturing facilities are carefully engineered to promote the efficient and safe processing of material resources. The field of manufacturing engineering, for example, includes plant layout, material handling, time and motion studies, and tooling development. Production planning and control activities are necessary for the effective coordination of labor, machinery, and raw materials. Managerial tasks such as scheduling, dispatching, and expediting are common in all manufacturing ventures.

In modern society, manufacturing is often referred to in the context of the Fortune 500 listing. Corporate names and products are familiar to people due to promotional media and marketing trends. Many citizens also recognize the importance of the integration of research and development, production, marketing, financial affairs, and human (employee) relations efforts, due to popular media techniques and the work experiences of family members. Individuals relate to the systems and products that have the most impact on their lives, whether as employees, managers, investors, voters, or members of a community.

Finally, the future of manufacturing will be more closely linked to educational performance, rather than to locations of material resources, political arenas, or traditional rust belt regions. Thurow (1992) suggests that the seven key industries of the coming decades will be microelectronics, biotechnology, newer materials industries, civilian aviation, telecommunications, machine tools and robotics, and computer hardware and software. Furthermore, he notes that all of these industries use "... brainpower.... Each could be located anywhere on the face of the globe. Where they will be located depends upon who can organize the brainpower to capture them" (p. 45). Hence, the importance of adequate schools and training institutions is underscored.

MANUFACTURING IN TECHNOLOGY EDUCATION

It has become increasingly evident that our future is dependent on today's students, as they will soon be the vital human assets required in our technological world. The National Center for Manufacturing Sciences (1990) notes the differences in old and new manufacturing with this observation:

> Traditionally, workers have been viewed as a part of the production process, much as machines have. Repetitive work was accomplished, people could be moved in and out of a job without disruption, and little or no decision making was required. Since little knowledge and minimal skill were required, the pool from which to draw workers was very large.... [and] workers were usually trained on the job and remained with the company for the duration of their work lives. Today, however, advanced technology in the manufacturing environment requires workers who can act as managers of machines and processes—workers who have much higher levels of skill and knowledge than their predecessors. (p. 14)

Cohen and Zysman (1987) expand this viewpoint to include the notion that "labor as a factor of production is not just people, but people with particular skills, attitudes, and habits" (p. 228).

One of the major goals of public education, therefore, should be to help individuals understand the importance of the productive sector and, thus, be better prepared in future roles as citizens, voters, leaders, and workers. During their K-12 experiences, students should concentrate on the topics associated with the design, production, and use of industrial outputs. Another central theme should involve assessing the impacts of products and systems on society and the environment. No curricular area is better prepared to accept this important agenda than the technology education program.

Current manufacturing programs reflect years of curricular development in the areas of industrial arts, industrial technology education, and technology education, as shown in Figure 9–1. The momentum of modern course work evolved from curriculum projects such as the American Industry Project and the Industrial Arts Curriculum Project (IACP). Lux (1981) estimated that the IACP's World of Manufacturing program was introduced into 15% of the schools in the United States during the 1960s, with parts of the curriculum adopted by numerous other programs. The American

Significant Developments in Manufacturing Education

1960s – American Industry Project
IACP World of Manufacturing

1970s – Stanley Tools Mass Production Contest
Manufacturing Forum magazine

Early 1980s – Jackson's Mill Curriculum Project
Industry & Technology Project
Technology Education Symposium Series
State Curriculum Projects (New York, Illinois, etc.)

Late 1980s – Center for Implementing Technology Education (CITE)
TECA/SME "Live" Manufacturing Contest
Numerous State and Local Projects
SME/CITE Manufacturing Guides
Integrated series of mfg. textbooks (for each level)

1990s – Elementary School Manufacturing Programs
TSA (High School) Student Competitions
Math/Science/Technology Projects
1993 CTTE Yearbook
Design and problem-solving textbooks

Figure 9-1: The evolution of manufacturing content within technology education programs.

Industry Project focused on technological endeavors from the commercial perspective, rather than as a collection of materials, inputs, or careers.

The Industrial Arts Curriculum Project (IACP) influenced the profession in very significant ways. Due to its level of federal funding, implementation workshops were held across the United States and support materials were readily available to classroom teachers. Overhead transparencies, student handouts, laboratory devices, textbooks, and related materials were part of the integrated program. Teachers could be handed literally an entire instructional program, and many accepted this structured curriculum as the easiest means of implementing manufacturing topics. The impact of the IACP was summarized by Lux (1981) when he stated, "no more successful effort in the redirection of industrial arts can be cited. This success must be in part attributed to the production of complete instructional systems and their effective dissemination" (p. 217).

Other people in the profession built on the content and activities associated with the Industrial Arts Curriculum Project during the late 1970s and early 1980s. The editorial team that formed the *Manufacturing Forum* at Ball State University, for example, helped promote the study of enterprise topics in the industrial arts curriculum. The *Manufacturing Forum* continued for 12 years and included useful articles on developing production systems, tooling, inspecting, packaging, and organizing and conducting classroom enterprises. It also printed articles on human and financial matters and product suggestions. This publication, with an annual subscriber base of 300–400 educators, kept the profession's focus on the topic of manufacturing as the field was evolving into the broader area of (industrial) technology education.

The Stanley Tools Mass Production Contest was a popular competition during most of the 1980s. This competition (open to manufacturing educators at all levels—middle school, high school, and college programs) was conducted in the exhibit area at the annual American Industrial Arts Association/International Technology Education Association conferences. Successful efforts in mass producing simple products were highlighted along with the enterprise activities linked to the laboratory efforts. While national programs such as Junior Achievement focused on the business aspects of manufacturing, the Stanley Tools Mass Production Contest featured tooling and inspection systems, line organization and detailed paper work, and examples of student assembled products.

More recently, competitive events for the Technology Student Association (TSA) and the Technology Education Collegiate Association (TECA) students have encouraged teachers to include manufacturing in the curriculum. The TECA/Society of Manufacturing Engineers Manufacturing Contest is designed for majors in technology teacher education programs and is a quite popular contest at college and international conferences. Team members are prospective classroom teachers who will be better prepared, based on their competitive experiences, to include the study of manufacturing in their future teaching assignments.

A significant number of national and local initiatives have resulted in manufacturing topics being included in public schools over the past decade. The entire 1993 yearbook of the Council on Technology Teacher Education, for example, was devoted to the topic of manufacturing technology education. Numerous projects funded by the Society of Manufacturing Engineers (SME), the National Center for Manufacturing Sciences (NCMS), and the Junior Engineering Technical Society (JETS) also enhanced the curricular materials available for implementing manufacturing. These projects have resulted in the development of course guides, classroom activities, posters, etc., which are appropriate for all levels of schooling.

Manufacturing education today is an integral part of a dynamic technology program. Technology education is positioned in most schools as general education, or that learning vital for all students. Manufacturing course work at each level demands that students be involved in activities that support their general knowledge of a technological society. The focus is on understanding manufacturing devices, systems, and impacts. As Feather (1989) suggests, one of the basic requirements for future citizens is that they have "technological skills, especially the ability to understand the capability of modern technology" (p. 99). What is more important, however, is that manufacturing educators need to recognize they teach students, not just content. They must continually alter program goals, instructional strategies, and course offerings to follow the agenda of an industrialized society. Since most individuals will hold many different jobs throughout their productive careers, courses need to be implemented in order to prepare knowledgeable and productive citizens.

STATUS OF MANUFACTURING IN TECHNOLOGY EDUCATION

Contemporary manufacturing programs follow the design-product-use-assess model outlined earlier in this yearbook. Furthermore, action-based learning involves individual and group activities that foster cooperation, divergent thinking, resourcefulness, and problem solving skills. Instructional activities are selected for their appropriateness by grade level and student (learner) characteristics. Learning takes place in a facility that allows for flexibility and diversity in its design.

Many schools use the area of manufacturing to introduce units in technology-based content at the elementary level. A simple production line, for example, might be organized to illustrate the concept of system inputs, processes, and outputs. Young students often convert raw materials into attractive, useful products with table top technologies and systems. At this early age, the students discover many basics of productions systems that include the following:

- They learn the definition of manufacturing technology.
- They develop an understanding of manufacturing's influence on how people live and work.

- They learn how to study manufacturing technology using the systems approach.
- They learn how products are designed, engineered, produced, and marketed.
- They learn how manufacturing systems are operated.

As in all academic subjects, manufacturing content and activities at the junior high school and high school levels build upon the students' experiences in the elementary grades. A typical sequence includes an introductory course at the middle school or junior high school level. This generic course might include one or more modules related to product development, production techniques, and the operation of industrial enterprises. At the high school level, specific manufacturing courses are offered that address themes such as product and system design, industrial materials and processing, and manufacturing enterprises. Obviously, the course sequence will vary depending on the department size, student population, number of faculty, and types of facilities.

A typical manufacturing program is shown in Figure 9–2. This recommended program includes covering manufacturing topics starting at the elementary school level, taught by elementary teachers in existing classrooms. A school's technology education teachers should be encouraged to work with elementary teachers to assist them in introducing technology content. Additionally, a technology teacher, whose responsibility is to assist in all phases of implementation at the middle school, junior high school, and high school levels, should be available.

The type of junior high school or middle school program influences the way manufacturing content is taught. The content may be offered within an introductory technology-based course or in a separate course, for example, Introduction to Manufacturing Technology. This course would most likely be the initial course in a school's technology education department, and would be taught by a professionally trained technology educator.

Numerous instructional materials and textbooks are available for the junior high school and middle school manufacturing educator. Laboratory-based activities, for example, are disseminated individually (e.g., Center for Implementing Technology Education activities available from Ball State University or as resource inserts in *The Technology Teacher*) or as a series of modular units (available through commercial vendors). A number of manufacturing textbooks allow teachers to use a different book at each level. As the technology education field has progressed, manufacturing textbooks have become amazingly consistent in their coverage of content (Komacek,

Recommended Sequence for Manufacturing Programs

K through 6th

Elementary School Manufacturing Activities
- Definition of technology, manufacturing, etc.
- Introductory line activity
- Material processing experiences
- History of Inustrial Revolution, etc.

Junior High or Middle School

Introduction to Technology Course
- Introduction to materials and processing
- Teacher-directed line activity
- Product design experiences

Introduction to Manufacturing Course
- Introduction to product design sequence
- Materials and industrial processing
- Teacher-directed line activity

High School

Product/System Design Course
- Emphasis on product design process
- Manufacturing engineering
- Specifying product/system plans

Materials/Processes Course
- Cover material resources
- Emphasize industrial processing
- Material testing / evaluation

Manufacturing Enterprise Course
- Emphasis on industrial management
- Marketing, financial affairs, etc.
- Student-run production line

Industrial Research & Development Course
- Technical research sequence
- Product engineering

Figure 9-2: Topics and suggested sequence related to manufacturing technology for students in K-12 technology education programs.

Lawson, & Horton, 1990; Daiber & Erekson, 1991; Wright, 1990). Most introductory textbooks open with a section on the importance and evolution of manufacturing, include a middle section on inputs (tools, materials, people, etc.), and then highlight the activities of a typical manufacturing enterprise (product and process development, marketing, financial affairs, etc.).

The technology sequence offered at the junior high school or middle school level is critically important to a successful K–12 program. The courses in these grades are typically the only ones required for all students and should be used to promote the study of all technology-based content. It is imperative, therefore, that manufacturing experiences at this level be interesting and exciting, as well as educational. By the time students complete this level, the content and activities related to manufacturing technology should help them understand the following:

- The classification of manufacturing inputs, processes, and outputs.
- The types and characteristics of industrial materials.
- The primary and secondary processing techniques.
- The design process used to develop products and systems.
- The production and marketing of products.
- The operation of manufacturing systems.
- The organization and management of manufacturing enterprises.
- The consequences of manufacturing on individuals, society, and the environment.

While this is an ambitious listing of topics for a 12–18 week course, many of the design and engineering activities can be linked to a specific product theme or company goal. Classroom and laboratory activities can require students to complete design and production assignments similar to the daily assignments of professionals in manufacturing firms. Figure 9–3, for example, shows the application of a problem-solving model to developing products/systems.

Secondary school manufacturing programs allow students to study complex manufacturing topics in more depth. For example, the programs might concentrate on the sequence of activities related to product or system development. In addition, a course in materials and processes provides an examination into the methods of processing raw materials into useful stock. Capstone courses in research and development and manufacturing enterprises are popular for students pursuing a career in industry. While the goals

Applying A Problem-Solving Model To Developing Products/Systems

PROBLEM or OPPORTUNITY . . .

1) Define the problem or need
2) Develop alternative solutions
3) Select the best design
4) Prototype the solution
5) Evaluate the design
6) Redesign the solution
7) Communicate the solution

. . . OUTCOMES and CONSEQUENCES

Figure 9-3: Manufacturing goods and systems is typically developed using a technological problem-solving model.

and content for specific courses will vary by school and program, the courses in Figure 9–2 suggest a basic structure for a manufacturing program.

The major challenge for secondary programs is to match the appropriate needs of students with learning experiences in specific manufacturing courses. Classroom and laboratory activities should address the goals that serve as the focus of the manufacturing course(s). An integrated K–12 or 6–12 manufacturing program must be planned in each school and the topics and activities aligned with the approved curriculum. Unfortunately, manufacturing activities are too often implemented with little thought or instructional analysis on the part of the teacher. Activities involving CO_2 cars, designing containers for egg drop contests, or programming pick-and-place robots may be selected more on appeal, unfortunately, than on their contribution toward meeting educational goals.

High school manufacturing courses are designed to focus on students' skills and understandings of manufacturing practices. Due to the limited amount of time available for elective courses at this level, the manufacturing sequence must be implemented with a narrow theme in each course. A class

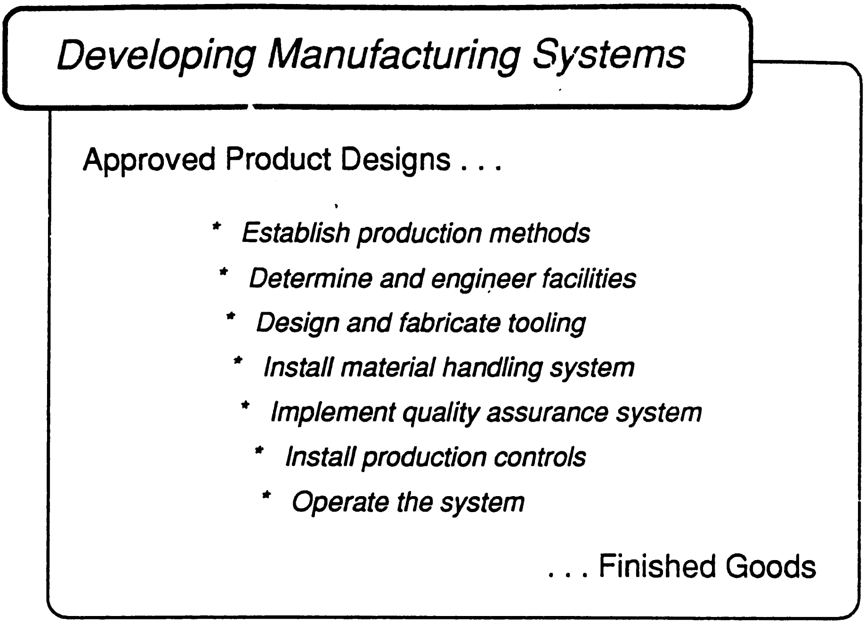

Figure 9-4: The process of designing and engineering manufacturing systems.

that addresses a manufacturing product or system design, for example, would cover the topics outlined in Figure 9–4. A one-semester course guide by Wright and Shackelford (1990) and numerous textbooks offer a more detailed scope and sequence of activities for course work of this nature. Unlike the other cluster areas in technology education, manufacturing has instructional materials commercially available for implementing multiple layers of classes, each with a narrow focus.

One topic usually reserved for the high school manufacturing teacher is the concept of an industrial enterprise, while teachers in the communication part of a technology education program often feature classes called Mass Communication, Telecommunication, or Broadcasting (all of which refer to service-related ventures). Since topics related to industrial organization and management cut across all technological systems, it is educationally sound to offer only one class associated with the formation and operation of managed systems. Manufacturing enterprises are preferred over transportation and construction enterprises due to logistics, capital requirements, safety factors, and/or time.

A high school enterprise course allows students to role play the daily activities of personnel in corporate settings. This type of class features the

Topics Featured In Manufacturing Enterprise Courses

Research & Development

* *Industrial research*
* *Product/process development*
* *Product engineering*
* *Engineering testing*

Production

* *Materials and processing*
* *Production planning & control*
* *Quality control*
* *Production*

Marketing

* *Packaging*
* *Advertising*
* *Sales*
* *Distribution*

Human Resources

* *Employment*
* *Corporate training / safety*
* *Public relations*
* *Union relations*

Financial Affairs

* *Corporate financing*
* *Purchasing*
* *Control (accounting)*

Figure 9-5: A manufacturing enterprise course combines technological and economic topics in a realistic setting.

activity areas of research and development, production, marketing, human resources, and financial affairs, as shown in Figure 9–5. When a mock corporate enterprise is developed, students learn how companies are organized, funding is obtained, and levels of authority are established. A division of labor illustrates the interdependency of workers, supervisors, and top management, and the teamwork typical of successful organizations.

A classroom enterprise also results in a salable product, which should ultimately produce a profit to investors of the venture. The profit motive is a powerful concept, since modern technology is the driving economic force in an industrialized world. While it is important to study devices and systems, students must also realize that technology is applied in human ventures with the singular goal of generating a profit (Wright, 1990; Daiber & Erekson, 1991; Seymour & Shackelford, 1993).

A standard high school manufacturing program features courses that build upon experiences from an earlier level. It is an appropriate time to introduce advanced topics related to production technology (automation, labor relations, batch production, etc.). Activities should be more student centered at this level, with very little teacher involvement in a student-staffed enterprise class.

FUTURE DIRECTIONS

Instruction in manufacturing course work at the public school level is influenced by many forces. Technology teachers, for example, have introduced a wide range of classes related to production systems and design and ergonomics themes, and individual courses covering the bio-technologies. In addition, calls for Tech(nology) Prep(aration) and work force literacy have come from administrators, parents, legislators, and industrialists. Many school boards have sought to implement vocational courses, primarily at the secondary level (e.g., comprehensive high schools and 2+2 programs). Finally, local manufacturers often impose self-serving expectations on community schools (Harmon, 1992).

Within the school, new curriculum models have been directed by variations of the math/science/technology theme and a return to the basics. It is imperative that all new curriculum development efforts be conducted with a continuous eye on desired outcomes. Educators have more challenges than simply insuring that students learn to read, write, and master basic mathematics. The agenda in a typical manufacturing program appears to enhance students' abilities, while preparing them for life and work beyond the elementary and secondary grades.

Naisbitt and Aburdene (1985) suggest that the individual and group skills related to creative problem-solving, leadership, rational thinking, entrepreneurship, and communication are skills that need to be developed. At the same time, Feather (1989) notes that attempts to create a futuristic curriculum must involve new teaching methods to prepare students to solve complex problems, increase math/science/technology understanding, become better able to work cooperatively, enhance decision-making skills, and, perhaps most importantly, learn how to learn. Classroom and laboratory-based assignments should address an individual's ability to understand a problem or opportunity fully, and then develop creative, practical solutions based on new and applied information. The assignments must challenge students to learn new information during the initial research phase and, ultimately, throughout all development tasks.

The importance of a cooperative attitude among workers and citizens in a technological society has become increasingly clear. Many schools have integrated disciplines and experiences to promote this theme. Manufacturing educators should convert some of their individual assignments into group activities that require knowledge from several disciplines. While design teams and enterprise activities are already common in manufacturing programs, cooperative activities should be emphasized at all levels. Teachers should stress the importance of collectively working as a unit to address daily problems and opportunities.

Recent curriculum models have forced the profession to examine topics not presently addressed in most manufacturing course work. The project that resulted in the document entitled *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990), identified the bio-related technologies (including agriculture and medical technology) as a major content area. The authors cited how bio-technology "applies biological organisms to make or modify products" (p. 17), including familiar industrial processes like fermentation and distillation. Certainly, advancements in the bio-technologies will be perfected and new applications discovered over the coming decades. Where and how this content will be introduced is a major issue facing professional manufacturing educators.

Current manufacturing courses review system inputs (or resources) with an emphasis on solid materials. One suggestion that might enhance the study of manufacturing at all levels is to incorporate activities related to liquids and gasses (along with their respective processing techniques). A course that covers refinery operations, for example, would allow students to study the petroleum cracking process, as well as to explore obvious interdisciplinary implications with the math and science program. Perhaps the most significant recommendation coming out of the most recent curriculum projects is that technology-based programs include an even more global view of materials, processes, and systems.

While several new curriculum models are content based, others have focused more on two specific technological actions—design and problem solving. Courses related to design topics are popular in certain schools (See Figures 9–3 and 9–4). Both design and problem-solving activities are emphasized in the British system of technology education. Future manufacturing courses and instructional activities should include specific models and routine processes. As new textbooks that address the activities associated with design and problem solving emerge, this content will likely be featured in more programs.

Finally, both the industrial sector and the educational community share common concerns and can often use similar initiatives to foster improvement in the curriculum. Manufacturing teachers should encourage partnerships with area industries for instructional and program purposes. Contributions of time, expertise, and materials (in addition to money) can be quite useful. Local firms can offer assistance by authorizing field trips or providing guest speakers. The manufacturing program can always benefit by using examples from local industries (quality control manuals, samples of plant layout drawings, old prototypes, etc.), since students' interest is heightened when they see familiar materials from nearby firms. Manufacturing educators may also help area firms realize their importance in the community. Reich (1992), however, notes that industrial support of education is often vague or self-serving, to the detriment of both institutions.

Continuous change is threatening to many educators, but is an important part of the context for studying technology. Some technological changes involve simple modifications in existing products, processes, or systems, while other changes are often referred to as advancements due to their positive benefit to society. Advancement is usually synonymous with terms such as progress, improvement, and contribution, thus, a program goal of manufacturing teachers should be to advance the entire program on a continual basis. The decision to teach manufacturing technology should inherently involve a commitment to program improvement.

SUMMARY

This is an exciting time for manufacturing educators. Suggestions for improving instructional efforts at the elementary and secondary school levels are being proposed and supported from a variety of sources. Continual curriculum change is imminent, as manufacturing is being implemented with the full endorsement of administrators, parents, school boards, civic leaders, and industrialists.

Manufacturing educators have a unique opportunity to shape the lives of all students in their programs. Teachers manage the classroom and laboratory activities, experiences, and behaviors of young learners. The characteristics of good teachers—pleasant personality, adaptability, knowledge, motivation, good leadership, and similar traits—represent the essential elements in manufacturing programs. Manufacturing teachers need to select appropriate models for an integrated K–12 experience. The content and activities for each course then should be identified, relative to the overall goals of the program. Specific topics should be presented in a constant manner. The major themes should include materials, industrial processes, product and system design, research and development, and enterprise organization and management. As students complete each grade level, they should know more about the dynamic world of manufacturing and the importance of this technology in society.

Finally, students in every school should have an opportunity to learn about the productive sector that dominates our free enterprise society. The practice of adding value to material resources is basic to our lifestyles. Stated another way, Waetjen (1989) reminds us that students must "learn how their nation earns and maintains its quality of life and standard of living. They must learn that technology affects social relationships, human values, and the very nature of work itself. They must learn to assess the role of business and industry in all of these processes" (p. 10). This knowledge is vital in preparing students for future roles as voters, consumers, workers, and managers.

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CHAPTER 10

Transportation Technology Education

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Transportation is an integral component of a web of technological systems that sustain our society. Americans often view access to transportation as a right, which they exercise vigorously. In an average year, each man, woman, and child in America travels more than 11,000 miles, totaling almost 3.5 trillion passenger miles. Most of these Americans also depend on transportation systems to provide all the necessities of life. According to the United States Department of Transportation (US DOT), "the food we eat, the clothes we wear, the medicines we take, the books we read, nearly all the essentials of modern life, are delivered over the transportation system" (1990, p. 2–1). Very few items or activities in our daily lives are not directly affected by the availability, reliability, and quality of transportation. Most people would find it difficult to identify even one item used in their home, business, or recreational activities that was not transported at some time.

Transportation also plays a vital role in the efficient operation of other technologies. Manufacturing companies use transportation systems to haul raw material resources from where they are obtained to production plants, even when those plants are halfway around the world. For example, Japan, the number one steel producer in the world, imports most of the natural resources it requires for steel production. Inside manufacturing plants, transportation systems such as conveyors, automated guidance vehicles, and other materials handling systems move materials and product components between work stations. Finished products are transported to commercial establishments where they are purchased by consumers, who then transport them home in their cars. Elevator, escalator, and pipe transportation systems are vital components to the operation of skyscrapers within the construction industry. In communication, space transportation systems are essential to the deployment and maintenance of telecommunication and observation satellites. Other technologies, such as medical and military, also depend on transportation systems, which play a vital role in making possible organ transplant surgery, mobile emergency medical teams, stealth technology, and intercontinental ballistic missiles. Efficient, reliable transportation systems are integral to the operation of many technological systems.

The development of transportation throughout history has changed our perceptions of time, space, and distance. According to the American Association for the Advancement of Science (1989b), transportation "has transformed the world in the past century, thereby bringing the world closer together" (p. 28). Today, travelers become anxious over one-hour flight delays or 10-minute traffic jams. In the 1920s, a trip across the United States required more than 26 hours (early prop airplane). The same trip today takes under six hours (current nonstop commercial jet airliner). If permitted, the SST Concorde could travel across the United States in about two hours, while NASA's space shuttle makes the trip in about nine minutes. In the 1860s, a trip across America by stagecoach lasted two months. Similarly, a trans-Atlantic flight that required more than 24 hours in the late 1930s can be made today in fewer than four hours by the supersonic transport plane. These improvements have had more than a personal impact on our society. According to DeVore (1992), "changes in the technical means of transportation . . . have brought forth increased interdependence among national economies, enhanced the role of technological innovation in economic growth and provided the means for the rapid expansion of global corporations" (p. 16).

Another indication of the importance of transportation is its economic impact, since transportation plays a key role in many economic activities. The US DOT described the relationship between transportation and the economy as "synergistic" when it stated that "economic activity generates transportation demand and transportation helps the economy grow" (1990, p. 2–1). According to DeVore (1992), the economic vitality of the United States "has been a result of the development of specialized forms of transportation that have linked farms to markets, oil wells to refineries, factories to consumers, homes to workplaces, and people to academic, cultural and recreational activities" (p. 15). Operating and maintaining a large transportation system creates millions of jobs. Transportation-related businesses provide roughly 10% of the total United States employment (10 million workers in 1988).

It is readily apparent that transportation is a very important part of our technological society. Coyle, Bardi and Cavinato (1986) summarized its importance in the following statement:

> Transportation is one of the tools required by civilized [people] to bring order out of chaos. It reaches into every phase and facet of our existence. Viewed in historical, economic, environmental, social, and political terms, it is unquestionably the most important industry in the world. Without transportation, you cannot operate a grocery store or win a war. The more complex life becomes, the more indispensable are the elements of transportation systems. (p. 4)

THE CHALLENGES OF TRANSPORTATION

Despite their obvious importance, transportation systems also pose significant challenges for the future of our technological society. Included among the challenges are the high cost of purchasing and maintaining transportation systems, the possible long term effects of transportation-related air pollution, and the unacceptable number of fatalities each year due to transportation accidents (Wright & Komacek, 1992).

The US DOT (1989) estimated that Americans spend $800 billion per year on transportation products and services, a sum which constitutes about 20% of the gross national product. Household expenditures for transportation exceed all others, except housing. Middle income families spend one of every five dollars on transportation or more than $4,500 per year on average. Most of these expenditures are for automobile purchase, operation, and maintenance. Paying the high costs of building and maintaining the infrastructure required for transportation is a concern for local, state, and federal government officials. Each year, tens of billions of dollars are spent on building and maintaining roads, bridges, tunnels, airports, and other transportation support structures.

Traveling is a safe endeavor. According to the US DOT, the least safe transportation mode insures the traveler a 99.99% probability of completing a trip without incident. Yet, with Americans traveling over 3.5 trillion passenger miles per year, injuries and deaths due to transportation accidents occur in alarming numbers. In an average year, there are over 20 million transportation accidents and nearly 50,000 fatalities, with over 95% of the fatalities due to motor vehicle accidents (US DOT, 1990).

Transportation is a major contributor to air pollution, with motor vehicles being the primary cause. Four important transportation-related air pollutants are carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), and hydrocarbons (HC). These pollutants are caused by burning petroleum-based fuels. Transportation accounts for 70% of the CO pollutants, which can cause medical problems ranging from headaches to death depending on concentration. Almost 25% of CO_2, which contributes to the greenhouse effect, is attributable to transportation. Transportation causes nearly 50% of NO_x and 33% of the HC pollutants. Hydrocarbons and NO_x combine with sunlight to create photochemical oxidants commonly known as smog. The NOx in the atmosphere contributes to acid precipitation.

As with any technology, transportation has positive and negative consequences that influence individuals, cultures, economies, societies, and environments. It is, therefore, a technology worth studying. The remaining sections of this chapter will examine the role of transportation studies in technology education. First, the historical evolution of transportation as a content organizer in technology education will be reviewed. Second, a definition for transportation technology education will be developed. Third, an overview of what is currently recommended or considered most effective when included in the transportation curriculum will be presented. Finally, sample curriculum and instruction materials for elementary schools, middle schools, high schools, and teacher education programs will be examined.

HISTORICAL EVOLUTION OF TRANSPORTATION TECHNOLOGY EDUCATION

This section summarizes several significant events in the history of transportation curricula in technology education. The comprehensive review conducted by Rouch (1989) is the basis for much of the summary. According to Rouch, the first real use of transportation as a content organizer occurred when William E. Warner of The Ohio State University presented *A Prospectus for Industrial Arts in Ohio* (1934) and *A Curriculum to Reflect Technology* (1947). Both proposals recommended transportation as a content organizer because it was such an important socio-economic force that affected the status of our current civilization (Warner, 1934). Transportation was viewed as a study of various vehicles, their support systems, and their economic influence.

While at The Ohio State University, Warner advised several master's candidates whose theses (Aman, 1951; Belton, 1949; Kleintjes, 1947; Tierney, 1949) focused on teaching transportation. Their methods included producing vehicles (often models), studying the impacts of transportation on society, and analyzing vehicle operations. In 1947, Kleintjes implemented the first transportation content organizer in a teacher education program at Oswego, New York. In 1963, Olson's book, *Industrial Arts and Technology*, envisioned the study of transportation to "include both the manufacture of the equipment and the operation of the transportation systems" (p. 137). In order to write the book, Olson adapted the doctoral dissertation that he had completed at The Ohio State University under Warner's mentorship.

In the mid-1960s, two curriculum projects that offered the profession very differing views of transportation as a content organizer were developed. The American Industry Project (Face & Flug, 1966), which was developed at Wisconsin-Stout State University, supported the inclusion of transportation as a content organizer. The second, called the Industrial Arts Curriculum Project (Towers, Lux, & Ray, 1966), was developed at The Ohio State University. Rouch (1989) characterized this project as a "major ideological setback . . . to the transportation organizer" (p. 29). According to Rouch, the Industrial Arts Curriculum Project viewed transportation "as just a support to industry and not significant to the point of including it as a major area of study" (p. 29).

DeVore (1970) proposed the use of a taxonomic analysis of transportation to identify content. In 1983, DeVore edited a textbook entitled *Introduction to Transportation*. One chapter in the book, "Transportation Systems: Environmental and Technical," provided a comprehensive taxonomy of transportation technology. This chapter, written by Myron Bender of the University of North Dakota, supported DeVore's earlier proposal. Peterson's (1980) doctoral dissertation used DeVore's taxonomy to identify 75 key technical concepts germane to the study of transportation. Fales' (1975) doctoral dissertation involved designing and testing an activity-based transportation course that focused on management and production concepts. According to Rouch (1992), "Fales' work was an innovative shift from transportation curricula which was focused on the automobile and the other hardware of transportation systems" (p. 30).

The *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) document identified transportation, communication, construction, and manufacturing as the four major technical adaptive systems. This document followed Fales' lead by focusing on the productive and managerial aspects of transportation. In the 1980s and early 1990s, several technology education publications included transportation as a content organizer, following the recommendations of the Jackson's Mill document. A few of the more important publications are *Industry and Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers* (Wright & Sterry, 1983); *Technology Education: A Perspective on Implementation* (International Technology Education Association, 1985); *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990); and *Teaching Technology: A Teacher's Guide* (Wright, Israel, & Lauda, 1993). Even one association outside the field supported the inclusion of transportation as a content organizer for technology education. *Project 2061: Science for All Americans* (American Association for the Advancement of Science, 1989a) identified transportation and 10 other technologies "important for the graduating high school senior to know" (p. 13).

Despite its apparent theoretical adoption as a content organizer in recent years, classroom teachers have not implemented a transportation technology curriculum extensively. Several authors have described transportation technology as the least understood, least accepted, and least developed of the technology systems areas in terms of curriculum development and implementation (Helsel & Jones, 1986; Komacek, 1992; Rouch, 1989; Rouch, 1992). The annual survey reports by Dugger and others through the years have substantiated these claims. In an initial survey, Dugger (1980) found only 8 transportation courses in a sample of 5,259 industrial arts courses across the country. Transportation course offerings had grown to 13.7% of the total in 1991, but still lagged behind the technology areas of communication and manufacturing by a wide margin (19.1% each). All the technology areas lagged behind the three key traditional industrial arts areas of general metals (27%), drafting (41.5%), and woodworking (41.5%) (Dugger, French, Peckham, & Starkweather, 1992). Colelli (1989) called the discrepancy between contemporary curriculum theory and the practices of in-service teachers in technology education the theory-practice gap. Much of the theory-practice gap, with regard to transportation, has to do with the continuation of energy and power-related courses that focus on energy sources, energy converters, and power transmitters. Several states and agencies continue to support energy and power-related curriculum organizers in addition to or with transportation. Most transportation-related textbooks for technology education include the study of energy and power as separate entities.

DEFINING TRANSPORTATION TECHNOLOGY EDUCATION

Transportation technologists often use complex definitions for their field of study. Papacostas (1987) defined transportation as "consisting of the fixed facilities, the flow entities, and the control systems that permit people and goods to overcome the friction of geographical space efficiently in order to participate in a timely manner in some desired activity" (p. 1). The complexity of the definition forced Papacostas to define fixed facilities (e.g., roads, tracks, harbors, airports, etc.), flow entities (e.g., vehicles, container units, railroad cars, etc.), and control systems (e.g., vehicular on-board speed and direction controls and off-board guidance and information systems). Papacostas poked fun at the complexity of the definition when he suggested that "overcoming the friction of geographical space" was a very awkward way of saying "to move from point A to point B" (p. 1). Several technology education publications, including the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981), *Technology Education: A Perspective on Implementation* (International Technology Education Association, 1985), and *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990) have used similarly complex definitions for transportation. The Jackson's Mill symposium participants defined transportation as follows:

> A technical adaptive system designed by people to efficiently utilize resources to obtain time and place utility and to attain and maintain direct physical contact and exchange among individuals and societal units through the movement of materials/goods and people. (Snyder & Hales, 1981, p. 36)

Transportation technologists know that "to obtain time and place utility" and "to attain and maintain direct physical contact and exchange" mean to move something or someone from one place to another.

The definitions from Papacostas and the technology education documents are for the technical adaptive system of transportation. Transportation technology education is a field of study and, therefore, requires a different definition. A definition of transportation technology education should be consistent with definitions of transportation and of technology education. In *Teaching Technology*, Wright, Israel, and Lauda (1993) defined technology education as "an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (p. 6). Combining the definitions of technology education and transportation produces the following definition for transportation technology education:

> Transportation technology education is an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems for the purposes of moving passengers and freight, and in assessing the appropriateness of technological actions. (Komacek, 1993, p. 1)

More detailed definitions are available, but the key technological actions (i.e., designing, producing, using, and assessing) and the basic purposes of transportation (i.e., moving passengers and freight) are combined in one easy-to-understand definition. The technological actions accurately describe what technologists do and, therefore, what technology students should do. Despite the complex definitions of transportation, its key features involve moving people or freight from one place to another. To technologists and nontechnologists alike, this definition clearly states that learners in a transportation technology education class will design, produce, use, and assess transportation products and systems.

CHARACTERISTICS OF CONTEMPORARY TRANSPORTATION CURRICULA

In this section, a few of the characteristics of contemporary transportation curricula for technology education will be presented. A taxonomy of transportation content, the universal systems model, and a model for a transportation technology problem-solving method will be reviewed.

A Taxonomy of Transportation

DeVore's 1970 article set the foundation for a taxonomic analysis of the technical aspects of transportation. DeVore (1992) restated the importance of a taxonomy:

> Using the rules of taxonomy provides a way to classify knowledge and content in the technologies that provides a logical and agreed upon base with agreed upon terminology for curriculum construction. The result is a common base that meets the needs of general education which is concerned with common learnings based upon cultural universals.... This approach provides an accurate and agreed upon perspective of the content reservoir. (pp. 21–22)

The simplified version of the transportation taxonomy reviewed here has been presented and revised by several authors (Bender, 1983; Colelli, 1989; DeVore, 1970, 1992; Komacek, 1992; Snyder & Hales, 1981; Wright & Sterry, 1983) and is shown in Figure 10–1.

On the taxonomy there are three levels of classifications: environmental mediums, modes, and universal concepts. Transportation takes place in the environments of land (terrestrial), water (marine), air (atmospheric), and space. The two divisions in each environment refer to the two types of vehicles or systems that require different design, production, operation, and analysis considerations. The two basic categories of modes are freight and passenger. Passenger modes carry people, while freight is a generic term used for all other transported objects. Pipelines, conveyor systems, coal barges, oil supertankers, and trailer trucks are examples of freight modes. The lines connecting the environments to the modes show that freight and passengers are transported in each environment. The universal concepts on

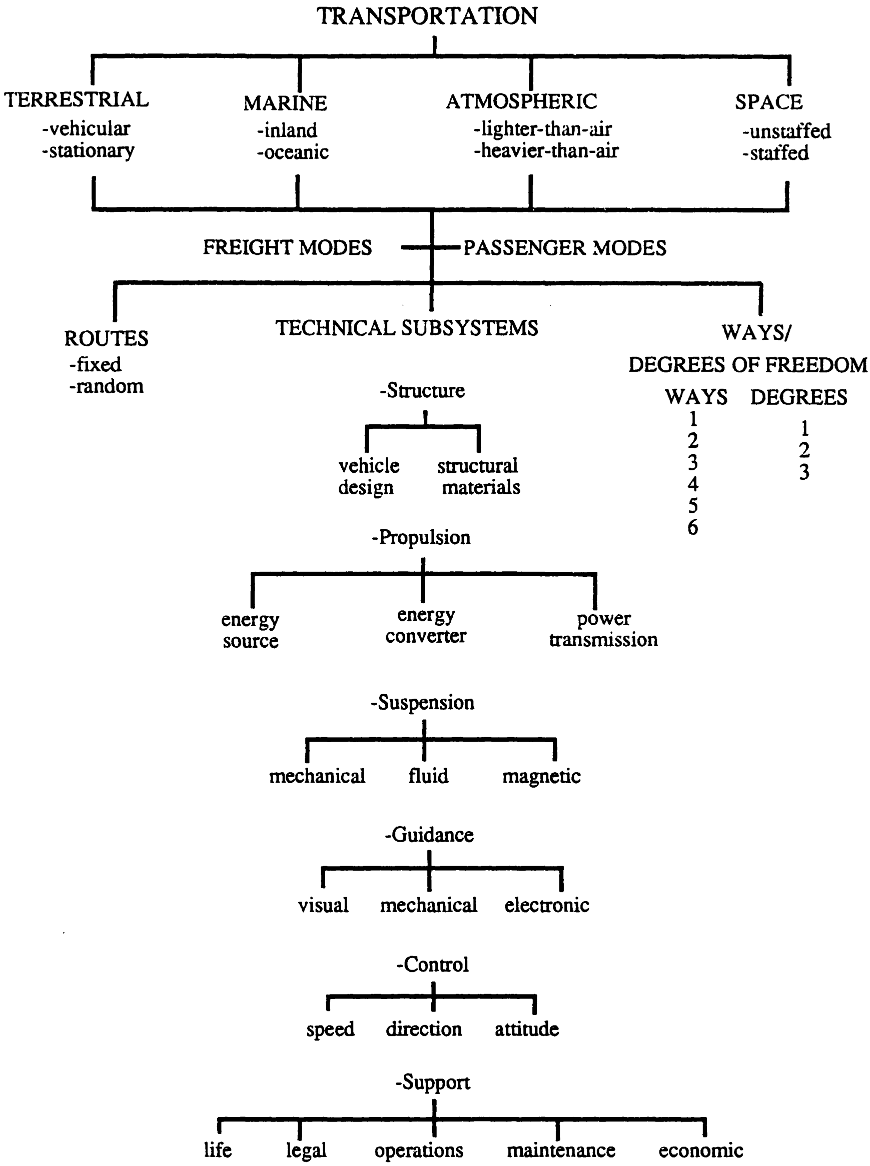

Figure 10-1: A taxonomy of transportation.

the taxonomy include routes, ways/degrees of freedom, and technical subsystems. Each of the concepts can be studied in any environment with any mode. Transportation routes are either fixed (rigid and inflexible, i.e., pipelines, tracks) or random (free and flexible, i.e., open water or airways). Ways/degrees of freedom describe the flexibility of vehicular movement. Vehicles move in the direction of three axes (longitudinal, lateral, and vertical) in a limited number of ways (one to six different ways). Airplanes, for example, travel forward (in the direction of the longitudinal axis), left and right (in the direction of the lateral axis) and up and down (in the direction of the vertical axis). Based on these movements, airplanes can be described as vehicles that can travel five ways (forward, left, right, up, and down) and have three degrees of freedom (in the direction of the longitudinal, lateral, and vertical axes). Vehicles that travel one or two ways (e.g., elevators, pipelines, railed vehicles) usually require expensive pathways to provide guidance and control and have simple on-board controls. On the other hand, vehicles that travel five or six ways (e.g., helicopters, submarines, Harrier jump jet) usually require complex on-board control systems and have simple pathways (usually open water or airspace).

The six technical subsystems are fundamental components in all types of transportation systems. Structural systems are the framework and body of a transportation vehicle or system. Propulsion systems provide the energy source, energy converter, and power transmitter to move a vehicle. Suspension systems connect or associate a vehicle with its environment. Wheels, springs, and magnetic levitation for land vehicles, displacement hulls for watercraft, lighter-than-air gases for aircraft, and reaction and gravity for spacecraft are examples of suspension systems. Guidance systems provide information to the operator of a vehicle. In automated vehicles, guidance systems provide information to computers that initiate action to control vehicle movements. Control systems receive information from guidance systems for the purposes of changing, altering, or regulating speed, direction, or attitude of a vehicle. Support systems provide life, legal, operational, maintenance, and economic support to the operation of transportation systems. Safety systems, highways, bridges, airports, maintenance, emergency services, laws, regulations and the economic factors related to transportation are examples of support systems.

Understanding the taxonomy provides a set of concepts that can be applied universally. Any vehicle, from a tricycle to the space shuttle, can be studied and analyzed according to its environments, modes, routes, ways/degrees of freedom, and technical subsystems. Teachers can use the taxonomy to identify the scope of the transportation field and the important technical components for transportation studies. Well-balanced transportation courses examine the universal concepts as they relate to various transportation systems in each environment. Several states have developed representative transportation curriculum guides (Indiana Department of Education, 1987; New York State Education Department, 1987; North

Carolina State Department of Public Instruction, 1988a, 1988b; West Virginia Department of Education, 1987).

Universal Systems Model

The universal systems model is a technique accepted by the technology education profession for helping young people understand the behavior of technological systems. Analyzing inputs, processes, outputs, and feedback breaks a complex system into small, more easily understood parts. The universal systems model has been reviewed, revised, and discussed extensively in the technology education literature. In this section, a review of the systems model will be limited to the various suggestions for transportation processes.

Three different types of processes have been proposed for transportation technology education: (a) Productive processes include receiving, holding/storing, loading, transporting/moving, unloading, and delivering (Savage & Sterry, 1990; Snyder & Hales, 1981); (b) managerial processes include planning, organizing, directing/actuating, and controlling (Savage & Sterry, 1990; Snyder & Hales, 1981); and (c) subsystem processes include structuring, suspending, propelling, guiding, controlling and supporting (Colelli, 1989; Komacek, 1992, 1993). As previously stated, the Jackson's Mill participants followed Fales' lead in focusing on productive and management aspects of transportation, which were also applied to the other systems areas. The rationale for focusing on subsystem processes is based on the assumption that transportation is not a productive technology, but provides the service of moving passengers or freight from place to place. Several state transportation curriculum guides include subsystem processes in their content outlines (e.g., Illinois State Board of Education, 1984; Minnesota Department of Education, 1986; New York State Education Department, 1987) while others include productive and management processes (Indiana Department of Education, 1987; West Virginia Department of Education, 1988). Two recent transportation technology textbooks do not describe the productive processes listed above when explaining transportation with the universal systems model, but do address the technical subsystems (Johnson & Farrar-Hunter, 1993; Schwaller, 1989). In terms of transportation instructional materials, the technical subsystems seem to have more widespread use. The universal nature of the subsystems makes them ideal for use in an instructional approach that revisits key concepts when studying different modes in each environmental medium. Still, it seems transportation technology education professionals have not reached a consensus on the processes of transportation.

Technological Problem Solving

The taxonomy and the universal systems model describe content. How to deliver content to students, however, may be a more important issue, since many students find school boring. According to Farrell (1990), "what makes a class boring seems to be how it is taught rather than what is taught" (p. 149). Technology educators have described several problem-solving strategies for content delivery (Bolyard & Komacek, 1992; Hatch, 1988; New York State Education Department, 1990; Page, Clarke, & Poole, 1982; Savage & Sterry, 1990; Waetjen, 1989). Some problem-solving models are complicated, difficult to implement, have numerous steps, and often cause confusion between technology and science (Bolyard & Komacek, 1992). One simple, easy to understand and easy to implement model for problem solving includes the four technological actions of designing, producing, using, and assessing. Variations of the model have been provided in the literature (Bolyard & Komacek, 1992; Komacek, 1992; Wright, Israel, & Lauda, 1993) but the essence of the technological actions is similar. Bolyard and Komacek referred to the technological actions as phases and provided numerous examples of instructional activities that engage learners in various combinations of designing, producing, using, and assessing transportation systems. They described four types of activities: comprehensive, three phase, two phase, and single phase. Comprehensive activities engage learners in all four technological actions and provide opportunities for problem solvers to move back and forth among designing, producing, using, and assessing. Freedom of movement among the phases allows learners the time needed to study the behavior of transportation systems in depth. Comprehensive activities are usually long duration and permit learners to make and correct mistakes. Engaging students in research and development is a common example of a comprehensive activity approach.

Three-phase activities emphasize three of the technological actions to facilitate the attainment of specific concepts. A common example is the use of Car Builder© software by transportation teachers to introduce concepts of computer-based automotive design, aerodynamic and track testing (using), and performance assessment. Three-phase activities are usually of short duration for the quick attainment of key concepts that can be applied in comprehensive activities (Bolyard & Komacek, 1992). Two-phase activities engage learners in two actions, are of short duration, and focus on the attainment of a few concepts. Experiment-type activities, such as those found in the module Lifting Forces from Airfoils, are typical examples (Appalachian Technology Education Consortium, 1992). Students test ready-made airfoils in a wind tunnel to assess the relationship between lifting capacity and aspect ratio. Single phase transportation activities are of short duration, focus on few concepts, and engage students in only one action—probably assessing. A representative activity is Automobile on Trial (West Virginia Department of Education, 1988) in which students prosecute or defend the automobile to assess its positive and negative impacts.

TRANSPORTATION TECHNOLOGY EDUCATION AT VARIOUS GRADE LEVELS

Technology educators believe all students, from elementary through high school, should study technology. Typically, at the elementary school level, students should become aware of technology through integrated studies, middle school level students should explore the basic technological systems, and high school students should analyze technologies in depth. This section will examine the role of transportation technology education at the elementary, middle, and high school levels and will review recommendations for teacher preparation in transportation technology education.

The Elementary School

The Technology Education Advisory Council (1988) supported the goal of technological awareness through integrated studies at the elementary school level. The council suggested that technology education at the elementary level "reinforces and enriches concepts in the sciences, mathematics, language arts, and other subject areas" and allows students to "develop an awareness of technology" (p. 17). Cupples (1992) reviewed curricula from several states that supported awareness and integration. He described how transportation activities could serve to integrate several subjects as follows:

> The activities may include the integration of reading to investigate a specific topic, writing and spelling to synthesize and report findings, science and math to explain physical changes, history to determine key foundational developments and social studies to define social and cultural consequences. In addition, students might construct working models and products that involve the use of tools, processes and unique materials. Finally, students may have the opportunity to become involved in the study of several careers. (p. 120)

The *Elementary Aerospace Technology* materials developed by the Los Angeles Unified School District's Elementary Industrial Technology Center (no date) are representative of the integrated approach to transportation

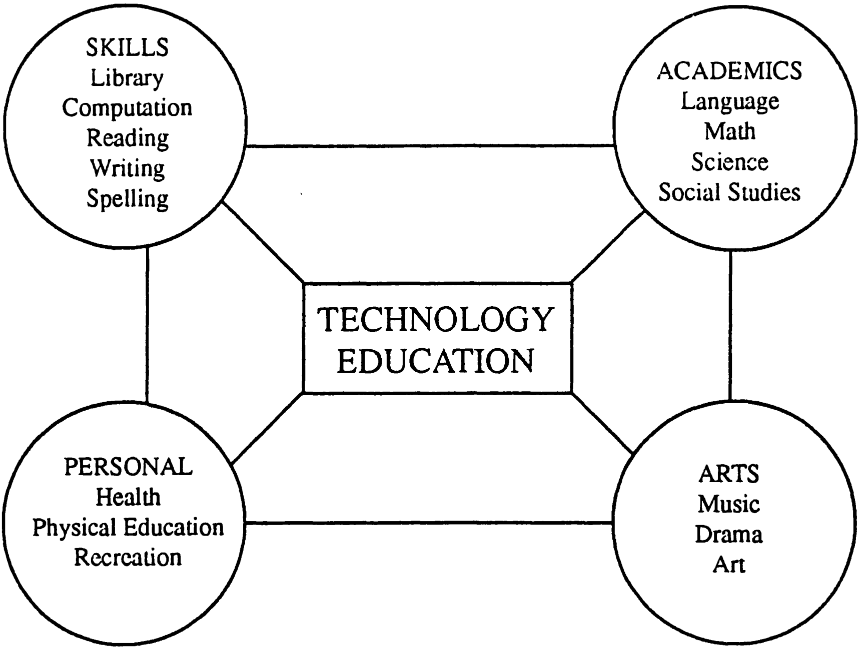

Figure 10-2: Technology education-center middle school model (Tracey, 1992).

technology education at the elementary school level. Transportation-related projects and activities provide a theme for the integration of mathematics, language arts, technology, science, and social studies. The Technology Education for Children Council has developed other representative materials such as *Elementary School Technology Education Classroom Activities: Packet 1* (Lucy, 1988).

The Middle School

Tracey (1992) reviewed middle school technology education recommendations that supported the goal of exploring technology. He also explained the importance of subject matter integration to the middle school concept. Tracey suggested a model as shown in Figure 10–2, in which technology education would serve to integrate the four organizational areas in a middle school: skills, personal well-being, academics, and arts. Several reports have called attention to the need for subject matter integration, particularly of technology, mathematics, and science (e.g., American Association for the Advancement of Science, 1989a; Technology Education Advisory Council, 1988; United States Department of Labor, 1991; United States Department of Labor, 1992). Integration is an important issue for technology educators at all levels. Technology education, with its emphasis on activity-based problem solving and real world contexts, provides excellent opportunities to integrate various subjects. While there are many ways to integrate subject matter, the technological application should be the focus of student learning experiences, with content and concepts from other subjects integrated to help students understand the behavior of technological systems.

Unfortunately, most technology education curriculum development for middle schools still focuses on isolated, not integrated, courses. The Pennsylvania middle school technology education curriculum guide is a typical example (Technology Education Association of Pennsylvania & Pennsylvania Department of Education, 1993). The guide provides three courses: Exploring Technology, Applying Technology, and Creating Technology. Integration of other subjects is not evident in the content outlines that focus exclusively on technology. Pennsylvania's inclusion of transportation in middle school technology education is also typical of what is done in most schools. Dedicated transportation courses are not provided, but transportation content is provided in concentrated units of instruction or as part of a unit focusing on other topics. Other states have followed this model (New York State Education Department, 1990; West Virginia Department of Education, 1988).

Fortunately, some integrative materials have been developed for instructional level activities. Three examples are the following: (a) the New York TLAs (Technology Learning Activities) that accompany the middle school curriculum guide (New York State Education Department, 1990); (b) the "T/S/M Integration Project" at Virginia Tech (LaPorte & Sanders, 1993); and (c) the technology/math/science modules developed in 1992 by the Appalachian Technology Education Consortium (ATEC) as part of a Technology Education Demonstration Project. The ATEC modules, which include the Lifting Forces from Airfoils module mentioned earlier in the chapter, integrate technology, math, and science content. Teams of three teachers, which included one teacher from each subject, participated in Teacher Capability Institutes to learn how to use the integrative instructional modules. Instructional modules similar to Lifting Forces hold promise for the development of integrative curricula.

The High School

The Technology Education Advisory Council (1988) described high school technology education as providing "an in-depth foundation for career preparation at the secondary and post secondary levels" while producing "outcomes related to scientific principles, engineering concepts and technological systems" (p. 19). Subject matter integration is also an important consideration for high school transportation technology teachers. According to Daiber (1992), "transportation courses offer an interdisciplinary appeal to numerous areas of the curriculum such as science, math, business, consumer education, geography, and other subjects which may relate to the movement of people or goods" (p. 164). It is important that technology teachers not become shop technicians for teachers and students of mathematics, science, and other subjects. Daiber addressed this issue by stating that "while transportation is easily integrated with other subject areas, it also has its own unique content dimension which is outlined by the technical and social/cultural content it provides for students' technology education" (p. 164). As with the middle school, most curriculum development for high school technology education is dedicated to transportation content, rather than to integration.

A key feature of high school technology offerings is diversity. At the high school level, students' needs begin to change as planning begins for college, postsecondary technical training, the work force, or military duty. Students select appropriate courses in preparation for this change. The diversity of needs among high school students requires variety in technology course offerings. Indiana's high school technology education curriculum is a typical example, with three levels of transportation courses being offered: exploration, specialization, and integration (Indiana Department of Education, 1987). Figure 10–3 shows the module titles for the transportation courses. Each course is designed for approximately one semester, which provides maximum scheduling flexibility for students. Content in the first two courses is consistent with the characteristics of transportation curricula described earlier in the chapter. The first level exploration course, Introduction to Transportation Technology, includes an examination of the systems approach (module 2), various vehicles and modes in three environments (modules 3–5), and the impacts of transportation (module 7). The second level specialization course, Transportation Systems, examines modes (module 2), environments (module 3), and impacts (module 6). Most of the instruction time is devoted to the technical subsystems (module 4). The third level integration course, Designing and Evaluating Transportation Systems, provides individuals or groups of students with the opportunity to research and develop a prototype transportation vehicle or system.

The West Virginia high school curriculum is another good example of the common focus in transportation courses on modes, technical subsystems, and impacts in each environment (West Virginia Department of Education, 1987). The course is mentioned here because of the excellent instructional materials developed by the state to support the curriculum. The instruc-

COURSE: Introduction to Transportation Technology

Module Number	*Module Title*
1	Introduction to Transportation
2	Transportation Systems
3	Land Transportation Systems
4	Water Transportation Systems
5	Space Transportation Systems
6	Energy Systems
7	Transportation and Society

COURSE: Transportation Systems

Module Number	*Module Title*
1	Introduction to Transportation
2	Types of Transportation Systems
3	Environmental Media for Transporting
4	Technical Systems in Transportation
5	Operating Transportation Systems
6	Transportation and the Environment

COURSE: Designing and Evaluating Transportation Systems

Module Number	*Module Title*
1	Analyzing Transportation Systems
2	The Design and Evaluation Process
3	Solving a Transportation Problem

Figure 10-3: Module outlines for Indiana's high school transportation technology education courses (Indiana Department of Education, 1987).

tional materials, called TARGETs (Teaching Activity and Resource Guide for Educators of Technology), were developed by teachers. They represent proven activities, provide comprehensive instructional details, and are available through the ITEA Technology Bank. Other examples of curricula or instructional approaches that may provide additional diversity for high school transportation programs emphasize aviation (Mickitsch, 1989), human-powered vehicles (Daily, 1989; Kyle, 1989), and supermileage vehicles (Ryerson, 1989). The Phys-Ma-Tech instructional materials provide a basis for the development of integrative curricula (Scarborough, 1991).

Teacher Education

The Council on Technology Teacher Education monograph entitled *Elements and Structure for a Model Undergraduate Technology Teacher Education Program* (Henak, 1989) recommended three levels of transportation courses. According to Rouch (1992), the course titles, descriptions, and learning outcomes are based on empirical research. Content in the first level course, Introduction to Transportation, includes the history of transportation, various modes, efficiency, technical subsystems, universal systems model, and the impacts of transportation. The second level course, Transportation Systems, which Rouch characterized as a "systems management type course" (p. 208), focuses on the management processes of planning, organizing, directing, and controlling as recommended in the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) and other documents. The third level course, Transportation Research and Development, is similar to Indiana's integration course with analysis, problem solving, design, and development of transportation systems emphasized. Rouch recommended that prospective transportation technology teachers take all three courses, while all technology education majors take the first two courses.

SUMMARY

Transportation is an integral part of our technological society. Transportation technology education helps young people to understand this important technology by engaging them in designing, producing, using, and assessing transportation systems. This chapter began with a review of the positive and negative aspects of transportation in our society, including technological interdependence, economic factors, related air pollution, and safety considerations. A review of the history of transportation in technology education indicated widespread adoption in the past decade without corresponding implementation by classroom teachers. The characteristics of contemporary transportation curricula were described with a review of a taxonomy, the process component of the universal systems model, a technological problem-solving method, and a definition of transportation technology education. Finally, representative samples of transportation technology education curriculum and instruction materials were reviewed for the elementary school, middle school, high school, and teacher education levels. A key consideration for transportation technology teachers is the development of integrative curricula.

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CHAPTER 11

Construction Technology Education

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The construction industry is an essential element of all societies. When referring to the American society, Robins H. Jackson (1992a), the president of the Associated General Contractors of America, reflected on the amounts of money Americans invested in construction over the last 10 years. He stated the following in the text of a letter to President-elect Bill Clinton:

> When construction activity was growing, our industrial facilities were busy producing everything that can be seen around you . . . From glass to steel, from cotton to wool to fibers, from furnishings to computers, from lighting fixtures to refrigeration and heating equipment, from pick-up trucks to heavy equipment, every center of production in America will be productive when the construction industry is even close to working at capacity. (p. 5)

A quick glance at our surroundings reveals that there are many outputs from the construction system. The construction industry provides the built environment and it consists of any and all structures that were produced where they are used. The built environment provides the surroundings in which people walk, sleep, eat, travel, work, and play. Structures shelter people and their possessions from the forces of nature—snow, cold, heat, rain, and wind—and allow them to live in any climate. Industrial buildings and complexes are used to produce and store materials and products used throughout the world, even in space. There is little doubt that people are profoundly affected by construction. The end results of construction activity are so much a part of our landscape that we tend to take them for granted.

DEFINITIONS

A consistent and understandable vocabulary is essential to communicate about construction effectively and efficiently. This section defines construction, construction technology, and construction systems for purposes of this yearbook chapter.

The conceptual model, as shown in Figure 11–1, illustrates three ways to describe construction projects: (a) structure types, (b) scale of construction projects, and (c) starting point for a project. Buildings and heavy engineering structures are two ways to categorize the different types of structures. Buildings provide physical conditions that people want and need for themselves, their activities, and their belongings. There are many forms of housing that shelter people from the weather and protect them and their belongings from danger. Commercial buildings house retail stores, offices, and other similar types of firms. They are convenient to the customers they serve, pleasing to the eye, easy to arrange in terms of space, and inexpensive to build and use. Health care buildings, prisons, and post offices are examples of institutional buildings. Industrial buildings include factories where manufactured products are made and where materials, parts, machines, and finished products are received, stored, and shipped. Most high-rise buildings (skyscrapers) are found in large cities where land costs are often quite high. Special purpose buildings are built for displays, sports contests, and transportation terminals. Heavy engineering projects include all other construction projects except building construction. The major kinds

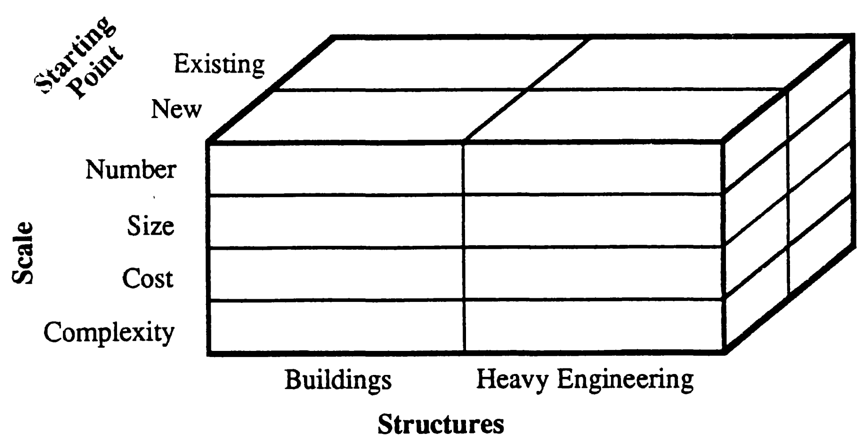


Figure 11-1: Types, scales and starting points of construction projects.

are industrial complexes, roadways, bridges, dams, pipelines, towers, ports, and tunnels. Most of these structures are designed by professional engineers.

The scale of a construction project can be described in four ways. They are the number of structures, size of the structure(s), cost of the project, and complexity of structures in the project. Construction may be initiated from one of two reference points. The project starts either as a new structure or with an existing structure that will be changed or modified. New construction often begins by clearing the site. One can modify an existing structure by remodeling, refurbishing, or restoring the structure.

All people participate at some level in the construction industry, but the key players are owners, design professionals, constructors, related businesses, regulators, and users. Figure 11–2 shows the key players in the American building enterprise. The current trend is to involve major

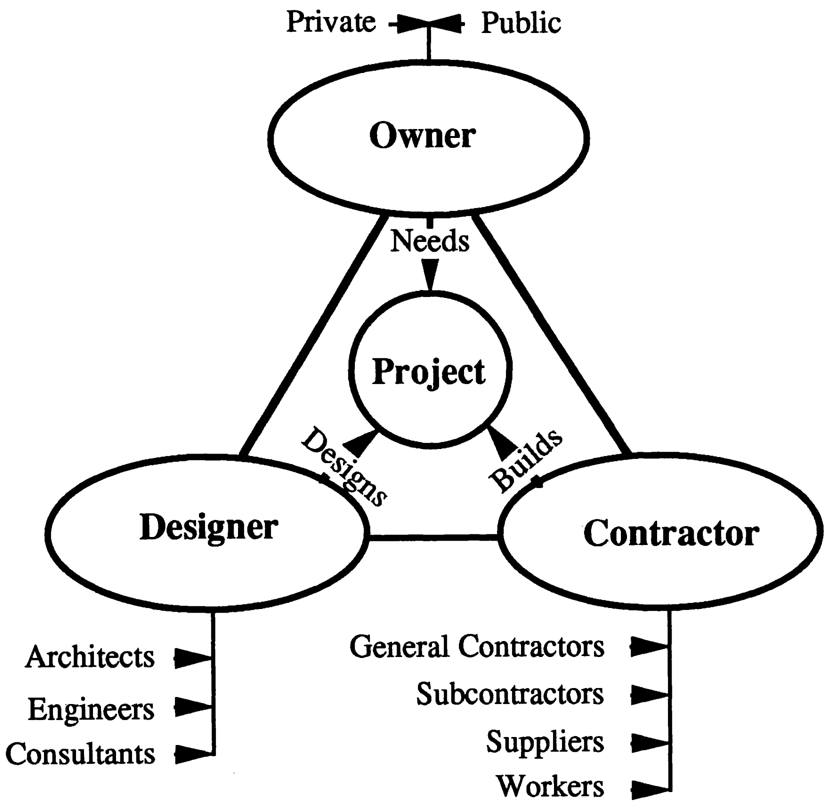


Figure 11-2: People who need, design, and build structures play key roles.

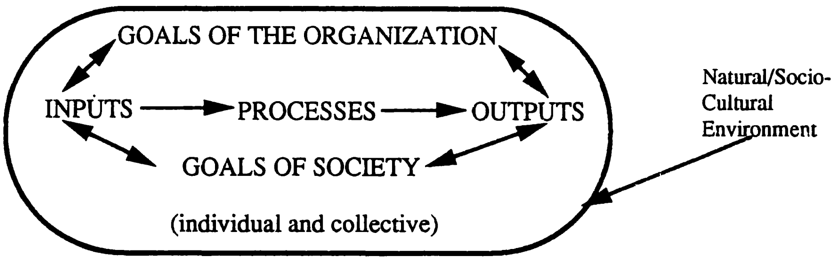
participants in nearly all phases of a construction project. The owner is the originator of the project and is usually responsible for identifying and leading the project team. Other participants are brought on board early so that their perspectives are represented in the discussions when alternative solutions are generated, developed, and selected.

The context in which construction functions is changing rapidly. Structures are more and more complex; their impact on the environment, people, and the economy is far greater than at any other time in history; large sums of money, reputations, and resources are at stake; and people work on project teams to design and build structures so they can more effectively control costs, time, and quality. Quality in a constructed project is defined as meeting the requirements (quality, schedule, and budget) of the owner, design professional, and constructor, while conforming to regulatory rules, laws, standards, and other matters of public policy (American Society of Civil Engineers, 1988).

Construction technology is the efficient practice of using productive and management processes to transform materials and to assemble components into buildings and heavy engineering structures built on site. The technology used to manage the productive processes often differs. Some projects are built by the owner's employees, but larger projects often consist of one, two, or many prime contracts that are subcontracted by the owner. Separate contracts may be awarded to design the structure, clear the site, build the structure, and design and build supporting roads and parking.

In the quest for higher quality, reduced time, and lower construction costs, new management processes are constantly being developed. Over the years, the linear, fast-track, and design/build project delivery approaches have evolved to reduce the time between initiating a project and occupying or using that structure. The Associated General Contractors of America has addressed improving quality in two ways. This association has adapted the total quality management concept used in manufacturing to the construction industry (Harrison, 1992). It has also developed partnering (Jackson, 1992b; Pruit, 1991) as an alternative way to resolve quality, scheduling, and payment disputes that often lead to costly, time-consuming lawsuits.

In the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) publication, the construction system was defined as "a technical adaptive system *designed by people* to efficiently utilize resources to build structures or constructed works on a site" (p. 30). Constructed works are typically fixed on a site and are not moved. Figure 11–3 graphically displays the unique features of the input-process-output model as it relates to the



INPUTS

- People
  - Skills
  - Attitudes
  - Knowledge (Personal)
- Knowledge (Accumulated)
- Materials
- Energy
- Capital (Plant & equipment)
- Financial

PROCESSES

PRODUCTIVE

- Preparing to build
- Setting the foundations
- Building the superstructure
- Installing utilities
- Enclosing the superstructure
- Finishing the project
- Completing the site
- Servicing the project

MANAGERIAL

- Planning
- Organizing
- Directing
- Controlling

OUTPUTS

- Structures on-site
  - residential
  - commercial/industrial
  - heavy/highway

Figure 11-3: Construction Input-Process-Output Model (Snyder & Hales, 1981).

construction system. Adaptations and new interpretations of this concept serve as the organizing theme for some current textbooks (such as that of Horton, Komacek, Thompson, & Wright, 1991).

HISTORICAL ANTECEDENTS

During the time period leading up to the early 1960s, few industrial arts education programs included content related to the construction industry. It was quite evident that many of the traditional approaches to industrial arts education were incapable of providing students with an adequate understanding of the impact of the construction industry upon our technological world. A rethinking and a major change in industrial arts education instructional content had to occur.

The Industrial Arts Curriculum Project (IACP) (Towers, Lux, & Ray, 1966) was the first systematic and thorough undertaking by the profession to develop a rationale and to conceptualize the structure of an organized study of industry. A basic structure of the body of knowledge that defined industrial technology with two elements—construction technology and manufacturing technology—was developed. The World of Construction (Lux & Ray, 1970a, 1970b, 1970c) course was selected as the initial experience in the junior high school program, and it contained a total instructional system. It was designed to provide a level of conceptual development needed by citizens to understand the construction industry. A task force of construction specialists provided the necessary details for the basic structure of the course. This structure was validated by a professional peer group and an advisory committee with consultants from other disciplines, the construction industry, and professional organizations.

Management and personnel technology and community planning concepts were added to production technology. The management content included initiating the project, designing and engineering the project, and selecting a builder. Personnel technology consisted of contracting, collective bargaining, hiring, training, working, advancing, and handling grievances with mediation, arbitration and strikes.

A position paper describing the criteria used to select learning experiences was prepared. An instructional system that consisted of an instructional handbook was developed, field tested, revised, and converted into an integrated package. In-service workshops were conducted and the program was pilot tested throughout the nation. An evaluation was conducted and then the instructional system was refined. Finally, an instructional system consisting of a textbook, a student laboratory manual, a teacher's guide, and suggested apparatuses was provided by McKnight & McKnight Publishing Company (Lux & Ray, 1970a, 1970b, 1970c).

In the last two decades, it has been reported that millions of students have been exposed to the program. The work of the IACP staff is reflected in many construction technology textbooks (Betts, Fannin, & Hauenstein, 1976; Henak, 1993; Lux, Ray, Blankenbaker, & Umstattd, 1982; Wright & Henak, 1993) and in state curriculum course guides such as *Exploring Construction Technology* (Wood, 1987) and *Introduction to Construction* (Indiana Industrial Technology Education Curriculum, 1992d).

In the mid 1960s, the goals, content, and activities for the industrial education profession had become confused. Controversy within and between the industrial arts and vocational education communities intensified. In his doctoral dissertation, Leslie H. Cochran (1968) analyzed 20 contemporary, innovative programs in terms of the influences that were shaping them at that time. He published his findings in a popular book, entitled *Innovative Programs in Industrial Education* (1970).

CURRICULUM ACTIVITIES OF THE 1980S

In the 1980s, confusion within the profession reigned as the literature in the field was replete with concerns and warnings about the direction and the future of industrial arts (Snyder & Hales, 1981). The Jackson's Mill Industrial Arts Curriculum Theory Symposium (Snyder & Hales) provided a rare opportunity for 21 dedicated industrial arts educators to develop and come to consensus cooperatively on a rationale for the field and to rededicate themselves to a common direction for the future of industrial arts. The major contributions made by the Jackson's Mill participants were the following guidelines: (a) continue the shift of focus away from materials and processes and toward industry; (b) expand the curriculum base to include communication and transportation; (c) study both industry and technology within the contexts of the universal systems model, the past, present and future, a global perspective, and the social and natural environments; and (d) consider the impact of technology (Snyder & Hales). The illustration provided by the Jackson's Mill participants for the input-process-output model of construction is shown in Figure 11–3. The sequence of construction productive processes included preparing to build, setting foundations, building superstructures, installing utilities, enclosing superstructures, finishing the project, completing the site, and servicing the project.

CURRICULUM ACTIVITIES OF THE 1990S

The subject matter of technology education, its organization, and methodology are all being challenged in the 1990s. Work by our national associations and efforts by individuals are impacting construction technology education. Construction technology was removed as an identifiable subject matter organizer (Savage & Sterry, 1990) and within three years reinstated (Wright, 1993). Efforts with a narrower scope are currently being made to produce more comprehensive, valid, relevant, and easily used organizers of subject matter (Henak, 1991) and to enhance the quality of the problem-solving experiences and image of construction courses (Boser & Gallo, 1994; Kirkwood, 1994; Komacek, 1994; LaPorte, 1994).

A CONCEPTUAL FRAMEWORK FOR TECHNOLOGY EDUCATION

The search continues for more relevant curriculum models, improved ways to respond to the changing needs of society, and more instructional strategies that will help people understand and effectively manage a rapidly expanding knowledge base. Currently, subject-oriented curriculum innovations are being challenged by process-oriented curricula, in which students learn to solve problems and make decisions. The core process of *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990) is problem solving. In this model, construction technology has lost its identity because manufacturing and construction are joined to form production. Unfortunately, manufacturing content is most often selected as the example to communicate material processing and management technology in the production system. While connections and differences between construction and manufacturing should be emphasized, they are often only verbalized or ignored.

THE TECHNOLOGICAL ACTIONS APPROACH

Construction regained its identity in the Technological Actions Approach, as identified by Wright (1993). Wright noted that this approach includes the following: (a) four technological actions—designing, producing, using, and assessing; (b) four technological contexts—communication, construction, manufacturing, and transportation; and (c) two societal contexts—personal and commercial/industrial. The Technological Actions Approach is used to produce artifacts and systems that satisfy wants and needs by solving problems and responding to opportunities. This model is useful to curriculum developers because it identifies the four basic and significant actions that effective citizens of a technological world employ, and it structures them in terms of their unique sequential actions.

PROJECT DELIVERY PROCESS

The Project Delivery Process (PDP) (Henak, 1994) evolved from a study of documents published by the American Institute of Architects (Haviland, 1987) and the American Society of Civil Engineers (American Society of Civil Engineers, 1988). These documents describe how members of the two

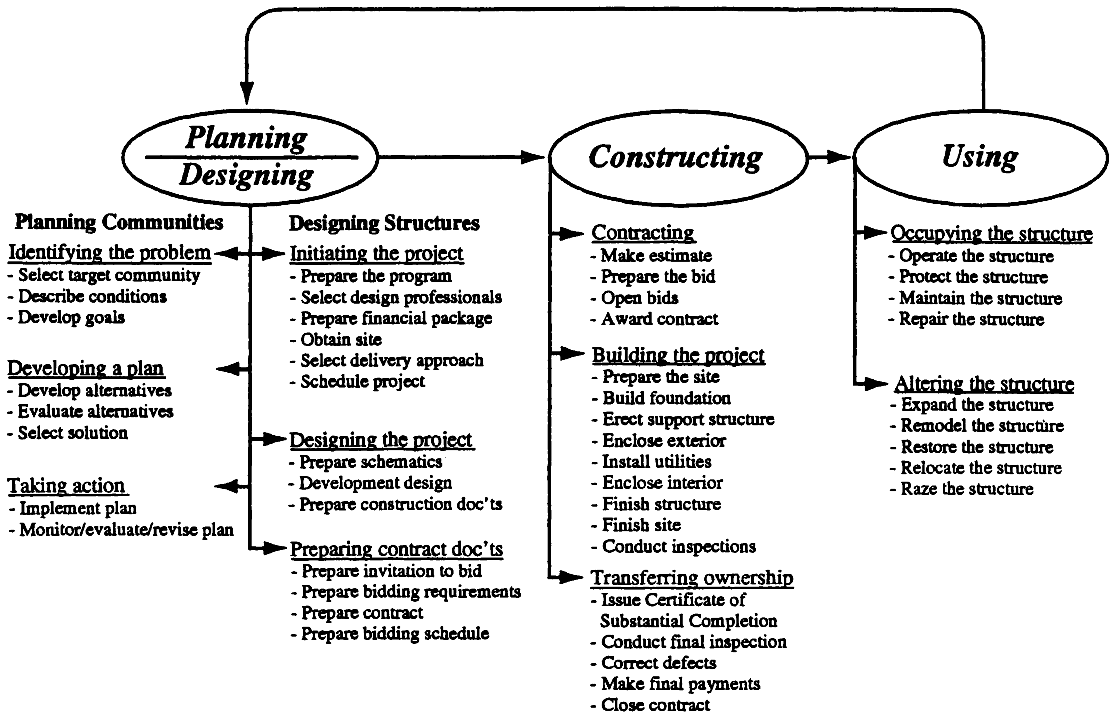


Figure 11-4: Project Delivery Process: A proposed subject matter structure for construction technology (Developed by R.M. Henak, D. Hobson, & J. W. Wescott. Reported in Henak, 1994).

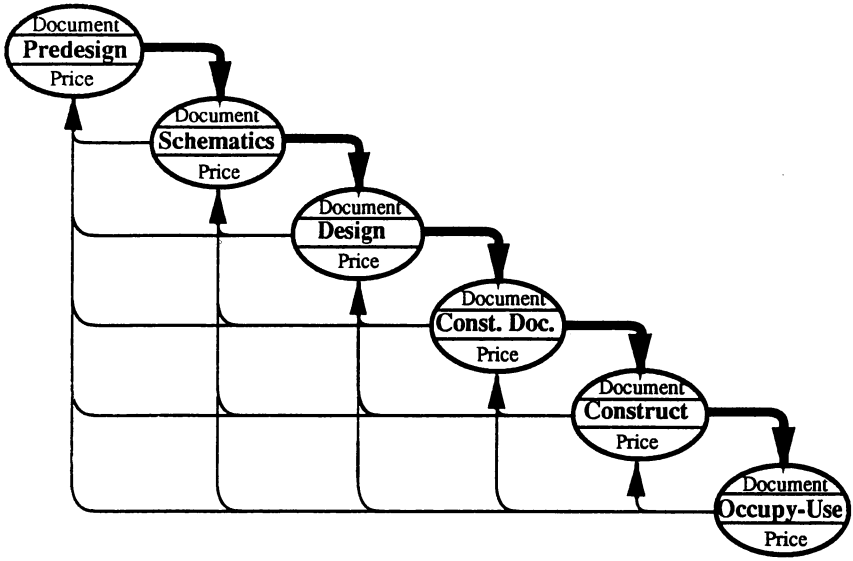


Figure 11-5: Phases and functions in the project delivery process.

associations should deliver professional services to the construction industry. The PDP begins when an owner initiates the project, design professionals design the structure, the constructor builds it, and, finally the owner uses the structure. Figure 11–4 is a conceptual model that shows the three process organizers and how each relates to the other. Designers of structures identify and convert the owner's needs into written and visual documentation that guides decision makers and constructors through the building process. Owners use structures and, when changes are needed, alter them. The actions of the people involved are presented in the six phases—predesign, schematic design, design development, construction documents, construction, and occupy/use—of the PDP. Each step of the process is documented and costs are estimated. See Figure 11–5.

CONSTRUCTION TECHNOLOGY IN SCHOOLS

Kirkwood (1994) suggested that construction content at the elementary school level, if taught as a study in and of itself, should be "more conceptual

APPROACHES	DESCRIPTION	STRENGTHS	CONCERNS
Enterprise	Business context Management and technical practices taught Learn skills as needed	Realistic settings Learn team skills Learn management & economic principles Learn about industry career opportunities	Residential type projects dominate Heavy financial investment
Interdisciplinary	Has central theme Several subject areas involved Most prevalent in elementary schools	Study disciplines in context with others Improves morale of faculty Observe connections	Schools structured with artificial boundaries "Turfdom" Limits content
Integrative	Coordination of two or more disciplines Teach parallel classes Use concepts taught in other classes	Emphasizes parallels in disciplines Can teach common content Joint planning	Requires common planning time Requires committed and compatible participants
Research Project	Students conduct actual research Teacher/students can identify problems Research report done M/S/T integrated with language	Students learn to discover information Learn research terms and procedures Individual differences easily addressed Encourages writing Good public relations	Burden for teacher when identifying problems Time consuming Process is more important than content
Systems	Based on generalized systems model Content often drives the model	Effective in widening residential construction content Way to organize thinking/instruction	Applying advantages difficult Principally a content approach
Conceptual	Based on a structure of knowledge Activities developed to form concepts Promotes coverage of content	Reduces rote memorization of facts Provides a framework on which to build knowledge	Model activities hard to develop May have too many cognitive concepts Product may become an end in itself
Simulation	Presents model of artificial reality Student plays a role in the model	An effective strategy Easy to initiate Computer games are fun and effective	Few computer games in technology Shortage of research in some areas
Model Building	Built as a vehicle of design expression or to show details of a structure	Has broadened the scope of technology education Devalues skill development	Can be overdone Requires patience and skill Takes much time for what is learned
Design Brief	Written synopsis of a a design problem Has a specific format	Applies problem-solving model Clear idea of the problem	Misconceptions can be drawn Lack of knowledge for solving problems

Figure 11-6: Summary of LaPorte's analysis of instructional approaches.

in planning, manipulative in carrying it out, and more focused on the child and the interdisciplinary nature of the curriculum" (p. 89). Boser and Gallo (1994) proposed that middle school construction technology education would be more effective if it included the following:

- An Introduction to Technology course at sixth grade that communicates the close relationships between bio-related, communication, construction, manufacturing, and transportation technologies and is closely articulated with upper-middle school and high school courses.
- A modular approach that is used in an Exploration of Technology course to study construction as a separate system but in conjunction with manufacturing.
- A closely articulated sequence of experiences based on competencies is developed and implemented at the exploratory level and integrated with the upper-grade levels.
- An implementation of thematic approaches in which mathematics, computers, and history are integrated. (pp. 110–115)

Komacek (1994) suggested that both the image and breadth of appeal would be improved if course content would do the following: (a) move beyond the technical plane and provide interdisciplinary opportunities, (b) shed the industrial perception, and (c) focus more on structural engineering. He went on to propose four construction technology courses—Construction Systems, Architecture and Construction, Structural Engineering, and Community Planning. LaPorte (1994) analyzed nine instructional approaches used to teach construction in technology education. His analysis is summarized in Figure 11–6.

STATE APPROACHES TO CONSTRUCTION IN TECHNOLOGY EDUCATION

The value that curriculum writers hold for specific subject matter or processes can, to some degree, be determined by the following criteria: (a) how high up the concept or process appears in the taxonomy, (b) the amount of actual class time devoted to it, (c) the degree to which it is used to provide an example of a concept, and (d) the level of refinement used to describe the concept. These criteria are used in the paragraphs that follow to describe the degree to which selected states have infused construction technology into their state curriculum guides. The approaches are arranged in descending order of construction technology's perceived value.

Indiana

The Indiana Industrial Technology Education Curriculum (IITEC) has the most comprehensive construction program, with four courses devoted to different phases of construction. The curriculum guides describe significant experiences in designing and engineering, constructing, and planning the built environment. The activities engage students in meaningful, creative problem-solving situations related to their lives, address current concerns and those of the future, and communicate an accurate view of the opportunities available in the construction industry.

The *Introduction to Construction Technology* (Indiana Industrial Technology Education Curriculum, 1992d) guide is organized to provide students with an overview of the entire PDP model. A view of the construction industry, as established by the IACP, is evident. The *Construction Planning and Design* (Indiana Industrial Technology Education Curriculum, 1992b) reflects the intent of a construction design experience. The scope of the subject matter includes initiating the project, completing predesign activities, and designing the project. It ends with completed contract documents. Design professionals—architects, engineers, and design consultants—and their interaction with public and private owners, constructors, related businesses, and regulatory agencies is the focus of this course. *Constructing Structures* (Indiana Industrial Technology Education Curriculum, 1992c) focuses on experiences in constructing the built environment and includes activities such as contracting, building, and transferring ownership. The constructor team plays the lead role in this course. Projects that incorporate as many building processes as possible are selected. The building processes are interlaced with management technology such as scheduling, managing cash flow, initiating change orders, performing periodic inspections, and making partial payments. Planning is another fascinating area of professional practice. *Community Planning* (Indiana Industrial Technology Education Curriculum, 1992a) provides a model for this experience. Planners use a planning process that includes three phases—description, prediction, and action—to plan the arrangement or use of many buildings or entire regions. Activities are designed to resolve current and future community concerns.

Mid-America Vocational Curriculum Consortium

The Mid-America Vocational Curriculum Consortium (MAVCC) is represented by the states of Arkansas, Colorado, Iowa, Kansas, Louisiana,

UNIT I: Overview of Construction Types of Construction Resources used in Construction Steps in Construction Construction Workers Education and Training Personnel Practices Labor/Management Construction and the Future **UNIT II: Construction Safety** Laboratory and Site Safety Personal Safety Housekeeping Practices Ladder Use Safety Rules - Power Tools **UNIT III: Design and Planning** Design and Engineering Process Types of Public Construction Projects Building Codes Building Standards and Material Specs. Soil Tests Legal Land Descriptions Working Drawings Cost Estimating Securing Building Permits Types of Bridges	**UNIT IV: Construction Preparation** Surveying and Equipment Contracts and Duties Securing a Contract Scheduling Construction Preparing to Build Site Clearing Earthmoving Equipment Excavating **UNIT V: Construction Processes** Foundation Types Foundation Materials Setting Foundations Superstructure Frames (Steel, Concrete, Wood) Erecting a Structure (Floors, Walls, Roof) Utility Systems Insulating Structures Enclosing the Exterior Enclosing the Interior Finishing the Project **UNIT VI: Project Completion** Landscaping Transferring the Project Final Inspection Closing the Contract Servicing the Project

Figure 11-7: Course outline for Exploring Construction Technology (Wood, 1987).

Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas. Technology educators from each of these states collaborated in the development of a technology education series, consisting of five publications that describe an exploratory course and four technology systems courses—Construction, Communication, Manufacturing, and Energy, Power and Transportation. Content in the *Exploring Construction Technology* guide is illustrated in Figure 11–7. The guide provides teachers with activities that are based upon performance objectives, information sheets, overhead transparency masters, assignment sheets, and tests with answer sheets for each unit. The activities are typical of those found in the IACP.

Texas

The Industrial Technology Education Curriculum Guide (Association of Texas Technology Education, n.d.) states that "... industrial technology education is an investigation of industry . . ." (p. 5). A model of the program is shown in Figure 11–8. The study of construction technology is found at the seventh and eighth grade levels in the Introduction to Industrial Technology I and II courses. At the high school level, it is in Level II: Exploratory Production Systems and Level III: Limited Exploratory courses. The content is organized to address the Texas State Board of Education's approved essential elements for industrial technology education. A suggested content outline was prepared and suggested activities are listed. The curriculum guide is supplemented with activity guides published by the Extension Instruction and Materials Center (EIMC) at The University of Texas at Austin. *Technology Systems* (Bridge, Glock, McQueen, Rider, & Towler, 1988), *Construction Technology* (Extension Instruction and Materials Center, 1984), and *Systems of Technology: Laboratory Activities in Production* (Barnes, 1985) are publications that describe many laboratory activities for the courses that include construction content. Most activities are teacher directed and are designed to be covered in one or a few days. Design briefs are interspersed among the teacher-directed, project-oriented activities.

Illinois

The Illinois Industrial Technology Education program includes four one-semester career orientation courses. They are Communication Technology, Energy Utilization Technology, Production Technology, and Transportation Technology. The *Production Technology Curriculum Guide* (Illinois State Board of Education, 1989) describes five units—Introduction to Production, Materials and Processes, Construction, Manufacturing, and Servicing. Construction Technology content includes design engineering, surveying and preparing the site, establishing foundation systems, building superstructures, installing utilities, enclosing and finishing, and marketing.

The writers of the curriculum state that the purpose for the Production Technology course is to (a) "help students develop an appreciation of the hands-on activities, technical advancements, technological impacts, and employment trends found within the . . . construction . . . industry," (b) "become more technologically literate," and (c) "orient students to the basic resources, technical processes, industrial applications, and technological impacts related to . . . construction . . . technology" (p. 87). The suggested units of instruction are mostly traditional (such as trusses; forming an enterprise; career opportunities; designing, planning and engineering traditional structures; scheduling; bidding; codes and permits; construction processes; and utility systems). Some units of instruction, such as community planning, non-traditional building techniques (for example, geodesic domes, pneumatic structures, tensile structures), construction in the future, and

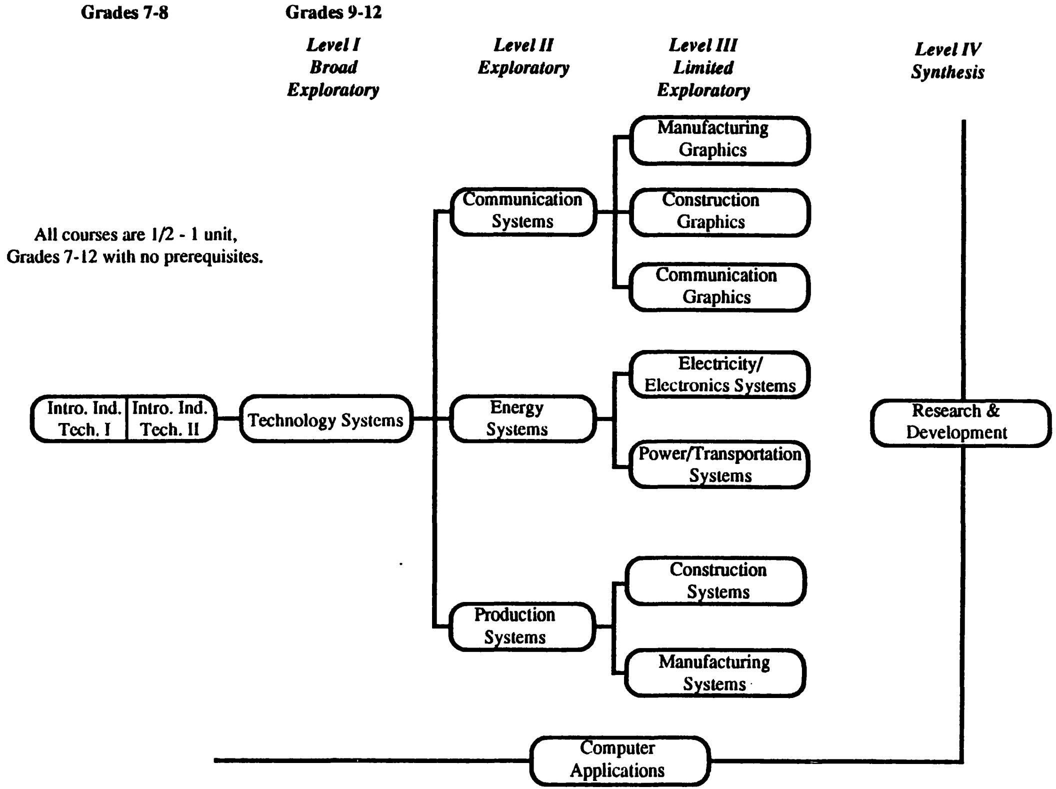


Figure 11-8: The Texas Industrial Technology Education Model (Association of Texas Technology Education, n.d., p. 13).

milestones in history, tend to make this an interesting and forward looking course.

Virginia

The Virginia Council on Technology Education for the 21st Century (1992) has developed a technology education model that encompasses grades K-12. The K-5 program is designed to "develop a technological awareness and to reinforce learning" (p. 11). The middle school technology education program focuses on "Explorations in Technology" (p. 15) and is designed to "provide active learning situations that help the early adolescent develop higher-order thinking skills" (p. 15). The purpose of the high school program is to "assist students in applying technology to their needs and in making intelligent judgments about problems associated with technology" (p. 19). Unlike the middle and high school programs, the elementary school program is not structured. Both of the upper level programs have three experiences/courses, each of which are designed to last between 9 and 36 weeks, as shown in Figure 11–9. The recommended middle school experiences are *Introduction to Technology* (Virginia Department of Education,

Middle School Program - Grades 6-8		
Sequence	**Experience/Course**	**Emphasis**
Grade 6	Introduction to Technology	Resources for Problem Solving
Grade 7	Inventions and Innovations	Creativity in Problem Solving
Grade 8	Technological Systems	Impacts of Systems
High School Program - Grades 9-12		
Sequence	**Experience/Course**	**Emphasis**
9-12	Design & Technology I	Technology Foundations
10-12	Design & Technology II	Technology Transfer
11-12	Design & Technology III	Technology Assessment

Figure 11-9: Virginia's Middle School and High School Technology Education Curriculum Models (Virginia Council on Technology Education for the 21st Century, 1992, pp. 14 & 18).

1988), *Inventions and Innovations* (Virginia Department of Education, 1989), and *Technological Systems* (Virginia Department of Education, 1990). Three levels of design and technology are recommended for grades 9–12. The only direct reference to construction at the middle school and high school levels is found in a construction systems unit in *Introduction to Technology* (Virginia Department of Education, 1988), and one experience in *Technological Systems* (Virginia Department of Education, 1990). In the first course, students learn about the elements of technology used in construction systems, designing and building models, solving problems, assessing impacts, and engaging in competitive events. In the second course, students are challenged to use ergonomics, information about the Japanese culture, and modern construction techniques to design and build a model of an affordable home and to present it to a developer.

Minnesota

In *Production Technology* (Minnesota Curriculum Services Center, 1986), a part of the Minnesota plan for industrial technology education, it is stated that the purpose of an educational system is to "develop a person's understanding of the world about him or her" (p. 11). The elements of production technology, as outlined in the plan, are shown in Figure 11–10. They include resources, technical processes, industrial application, and technological impact. Construction is categorized with manufacturing under the technical processes element. As is often the case when manufacturing and construction are categorized together, manufacturing dominates the structure and both categories are compromised because it is difficult to mix areas of study that are so different. A 4 1/2-week long unit and a semester unit in production technology are described in the curriculum guide. Both course formats use a list of learner outcomes to organize a comprehensive coverage of the elements described in Figure 11–10, but the lack of focus on construction or manufacturing persists and must be confusing for both the teacher and the student.

Considerable effort by knowledgeable and dedicated professionals is needed to identify relevant course outcomes and to find effective ways to develop essential competencies in our young people. LaPorte (1994) stated the following:

> Much work needs to be done in developing new approaches to teaching construction, determining their effectiveness, and disseminating them to the profession. Construction, in fact, may be the disadvantaged child of technology education. The parents assumed that everything was in order and gave the child little attention. In

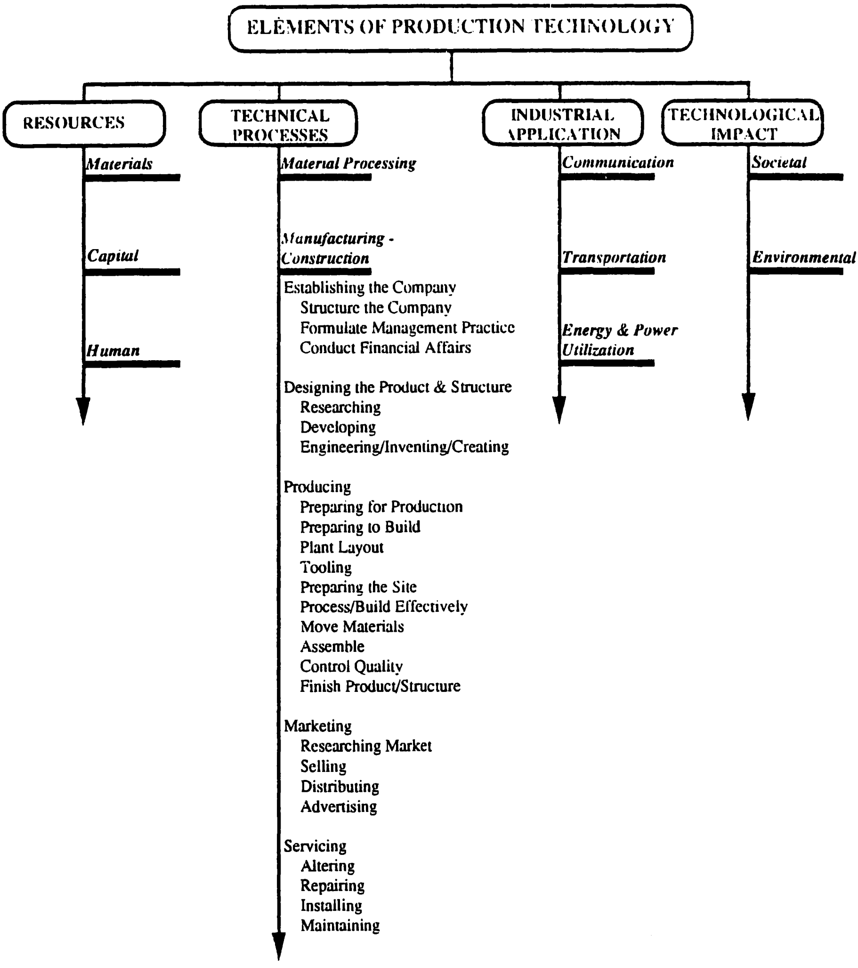


Figure 11-10: The Minnesota Model for the Elements of Production Technology (Minnesota Curriculum Services Center, 1986, p. 14).

> reality, the child has some deep-seated problems which can be eliminated with some attention. (p. 230)

In order to be effective, instructional designers must be fully aware of the nature of the construction industry in the future, identify valid competencies that have lasting value to students, and design relevant and interesting ways to engage students.

THE CONSTRUCTION INDUSTRY OF THE FUTURE

Ross (1994) wrote that the construction industry in the future will be characterized by certain trends, challenges, and projections. Technological advances, public and private sector relations, and pressure from market growth will fuel change in the construction industry. The industry will follow a trend toward pre-manufactured items that extend to large units like kitchens and bathrooms and, eventually, encompass entire structures. A positive move in the development of the construction industry is toward more government and industry partnerships. The areas of research and development, design, fabrication, and assembly will be the most productive. By having groups join as partners, the industry will improve substandard neighborhoods throughout the United States. Population growth, migration patterns, technology, public policy, and market growth will continue to outgrow the available supply of housing. The extent of new construction developments in the next few years will be unmatched by any time in history and will lead to a higher standard of living and a better environment for everyone. Land cost will continue to increase sharply as the pattern of rapid suburban growth continues to use large amounts of space.

Traditionally, people have thought of construction as building something on a site, but people's need for constructed structures is increasing while desirable land sites become more scarce. In the future, more structures will be built underground, underwater, and in the air over existing structures such as highways. In Osaka, Japan, rock from the tops of three mountains was crushed and used to build an island for an airport. It is about three fourths of a mile wide and 2 1/2 miles long and consists of 1,263 acres of land.

The real challenge is building structures in space. Some refer to space as our last frontier. Constructed structures in space are not built on a site and anchored to the earth. They are built at a site and held in space. Footings and anchors hold structures to the earth, while a balance of centrifugal and centripetal forces hold structures in space.

The present challenge is to understand, anticipate, and use change as an opportunity to improve efficiency and increase skills. According to Ross (1989), these changes will include management systems for the industry, development of participatory groups for problem-solving strategies, growth in research and development on the industry and building process, and recruitment. Presently, the construction industry should not worry about whether there will be an insufficient demand for constructed structures in the future. Contractors must recognize that stronger efforts will need to be made to increase the construction industry's efficiency by attracting groups with new areas of expertise. A demand for greater efficiency, economy, and speed will affect the development of pre-manufactured, off-the-shelf systems and complete structures. There will continue to be a need for industrial and commercial buildings and for housing, however, many of the structures in the future (for example, schools, sports facilities, and shopping centers) will be built for the collective enjoyment or benefit of large groups of people. In the working environments, future structures will include high levels of conveniences, high-quality human comfort, and improved visual quality.

The future contractor will continue to direct the construction project and the work that cannot be subcontracted. The method used to direct construction will vary with the contractor moving more in the direction of off-site fabrication and a reduction in the amount of field direction. In general, the future will require higher levels of expertise in both social relationships and technological processes, and less emphasis on the skilled crafter. Future contractors will need to develop competencies in understanding the environment, human needs, social criteria, the design process, and economic efficiency for delivering structures.

A FUTURE FOR CONSTRUCTION IN TECHNOLOGY EDUCATION

In the report of a study by the Construction Industry Workforce Foundation (CIWF), R. "Mac" Sullivan, Jr. (1989), the Secretary of the CIWF and Chairman of its Image Committee, stated that constructors felt the construction industry provided many interesting challenges and rewards for capable young people who wish to work at any career level. Constructors reported the following about the construction industry: (a) it offered many opportunities for earning while learning and for a fast-track career path, (b) it epitomized the small business entrepreneurial spirit of America, (c) it presented many interesting challenges and varied hands-on satisfaction, and (d) it provided great personal pride in seeing completed structures that had been built.

Unfortunately, construction courses in technology education classrooms have not been very popular (Dugger, French, Peckham, & Starkweather, 1992). The results of a 1990 CIWF study cited in Home Builders Institute (1991) indicated that junior high and high school students have a negative image of construction. The report stated that females felt excluded and that both males and females felt construction work was boring, tiring, stressful, dirty, and sweaty. Students felt that the workers have a rough demeanor and lacked prestige and respectability. While the CIWF's 1990 study found that many junior high and senior high school students seemed offended by some characteristics of the construction activity, an earlier study of constructors themselves had indicated that they seek challenging physical work outside in the fresh air and enjoy producing structures for all to see for many years. The challenge before technology educators is to develop courses that result in valid competencies and to use engaging strategies that project a positive image without glamorizing or misrepresenting construction activity. A valid construction program should do the following: (a) help secondary students to value the industry that builds, maintains, and renovates our nation's structures and directly or indirectly provides jobs for 20% of the workforce; (b) insure that graduates are able to respond positively and creatively to problems, issues, and opportunities they will experience in the future; and (c) make connections between construction technology and economics, languages, sciences, and mathematics.

Students need accurate information regarding career opportunities. Teachers of construction courses in technology education must find ways to improve the image of construction without conveying a glamorized, possibly deceptive view of the construction industry. Comprehensive construction programs should include effective productive and management practices used by owners, designers, and constructors to design, build, and use structures. Construction experiences should provide students with opportunities to use this generalized subject matter to design, plan, and construct a built environment that offers an improved higher quality of life, a favorable environment, sustainable energy resources, physical and mental well-being, and physical longevity.

Learning to learn has become an imperative in technology education so that students can renew and sustain their education throughout life. Developing learning skills alone, however, is not enough. The subject matter of construction technology must be selected for its ability to be generalized in human experiences. Traditional discipline-bound, fact-laden, point-of-practice construction courses are too narrow in scope to accomplish this goal. A curriculum based on materials or skills is often fragmented. Fragmenting the construction curriculum destroys the unity of the process used to design; build, and use the built environment.

There is a need for process-oriented courses that focus on the *journey* and on *how* work is accomplished, problems are solved, and decisions are made. Process-oriented construction technology courses must reflect current project delivery management and productive processes, approaches, settings, and relationships. Actions of owners who initiate projects, designers who convert the needs of owners into contract documents, constructors who convert construction documents and resources into structures, and owners who use structures are all potential roles students can play in a classroom setting.

WORKPLACE COMPETENCIES
● **Resources** - They know how to allocate time, money, materials, space, and staff.
● **Interpersonal skills** - They can work on teams, teach others, serve customers, lead, negotiate and work well with people from culturally diverse backgrounds.
● **Information** - They can acquire and evaluate data, organize and maintain files, interpret and communicate, and use computers to process information.
● **Systems** - They understand social, organizational, and technical systems; they can monitor and correct performance; and they can design or improve systems.
● **Technology** - They can select equipment and tools, apply technology to specific tasks, and maintain and troubleshoot equipment.
FOUNDATION SKILLS
● **Basic skills** - reading, writing, arithmetic and mathematics, speaking, and listening
● **Thinking skills** - the ability to learn, to reason, to think creatively, to make decisions, and to solve problems.
● **Personal qualities** - individual responsibility, self-esteem and self-management, sociability, and integrity.

Figure 11-11: Workplace competencies and foundation skills (SCANS, 1992, p. 6).

A report published by the United States Department of Labor, entitled *Learning a Living: A Blueprint for High Performance* (Secretary's Commission Achieving Necessary Skills, 1992), defines competencies that are necessary for a high performance workplace. The survey of a variety of American employers, supervisors, and employees found a clear pattern of requirements. Five "know-how" competencies and a three-part foundation of skills and personal qualities are needed for solid job performance. The competencies and skills shown in Figure 11–11 are described more fully in the Secretary's Commission on Achieving Necessary Skills (SCANS) Report. The message to teachers from the Commission is to "look beyond your discipline and your classroom to the other courses your students take, to your community, and to the lives of your students outside school. Help students connect what they learn in class to the world outside" (p. 6).

Traditional construction courses focus on the skills used to draw and build houses, skills which have limited appeal and utility. More students would benefit from a curriculum with a broader vision and one that reflects the expanding richness of construction technology. Subject matter in a construction technology program should include effective management and efficient processes used by owners, designers, and constructors to design, build, and use structures that are of high quality and are built on time and within budget. Activities should be based on current practices and sound economic principles. Real problems, such as designing structures for people outside of class or proposing a neighborhood revitalization plan, can be challenging, motivating, and satisfying. When appropriate, bidding, cash flow, scheduling, and decisions on construction methods should be supported by scientific principles, mathematical computations, and computer assistance. Accurate information regarding career opportunities for all people should be portrayed. It is as vital for people to learn how roadways, transmission lines, tunnels, pipelines, bridges, ports, and towers are designed, built, and used as it is to learn how low-rise wood frame buildings come into existence.

The instructional strategy often determines if teaching produces low-level learning or creative problem solving, critical thinking, and decision-making skills. Instruction can actually transform the way students think and feel about construction. This can be accomplished if instruction is couched in simulated settings in which authentic technical and management practices are used, significant issues are confronted, genuine problems are addressed, and accurate terminology is used.

Rewarding experiences are the ones that students find meaningful and enjoyable. Robert Marzano (1992), in *A Different Kind of Classroom: Teaching with Dimensions of Learning*, stated that, "Generally, we acquire and integrate knowledge because we want or need to use it" (p. 106). He describes decision making, investigation, experimentation, inquiry, problem solving, and invention as "common ways we use knowledge meaningfully" (p. 106). The curriculum should engage all students in active, meaningful participation in real experiences. Long-term, student-directed, applications-based activities are designed to provide purpose and direction to learning and tend to involve students (Marzano, p. 124). Student-centered, real world scenarios enhance interest. Life provides us with realistic settings for all kinds of learning, adds meaning, and facilitates classroom learning when daily problems, issues, and opportunities are addressed.

The image of construction and construction courses would be enhanced greatly if construction technology teachers would do the following:

- Find ways to make students active participants in their own learning.
- Repeatedly stress the importance of employees being able to work as a team.

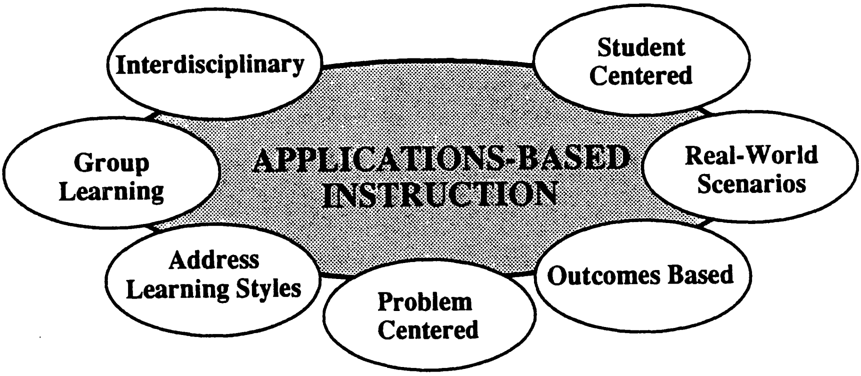


Figure 11-12: An applications-based model.

- Promote appropriate use of computers and calculators to enhance both the students' understanding of construction technology and their mastery of basic skills.
- Expect students to communicate about construction by writing.
- Encourage argument and discussion in search of solutions to real problems.
- Expect hard work and success.
- Make every effort to simulate the unique characteristics of the construction industry.
- Couch activities in realism.

Technology preparation (tech-prep), currently a school reform movement, holds considerable promise for technology education in general and construction in technology education in particular. The tech-prep curriculum is a high school program that parallels the college-prep program, is designed to replace the general education diploma program, and prepares students to enter the workforce or post-secondary technical programs. Applications-based instruction is the central thrust of the reform movement and holds the most potential for technology education. Figure 11–12 illustrates the major elements of the concept of applications-based instruction, which has the following characteristics:

- Is student centered and allows the students to do much of the decision making.

- Employs real world scenarios selected from local concerns whenever possible.
- Has carefully stated outcomes reflecting state or local proficiencies.
- Uses problem-solving methods extensively.
- Addresses learning styles by using a variety of techniques to teach and assess.
- Uses effective group learning strategies to enhance achievement, develop a positive self-esteem, practice social skills, and improve group participation.
- Integrates subject matter in appropriate ways.

SUMMARY

This chapter described the economic impact of construction technology, the usefulness of its structures, and the irony that most structures are taken for granted until they stop functioning. The terms construction, construction technology, and construction systems were defined.

The significant contributions by the Industrial Arts Curriculum Project in the 1960s and 1970s and their impact on technology education were described. The *Jackson's Mill Industrial Arts Curriculum Theory* document was the most significant contribution to construction technology in the 1980s. From the 1990s, two national efforts—the conceptual framework for technology education and the technological actions approach—and several individual efforts were described. Finally, some characteristics of the construction industry of the future were identified. Construction technology teachers were challenged to create construction courses. These courses must contain valid competencies, appropriate subject matter, and effective strategies that will produce a construction-literate populace able to participate in addressing current problems and issues, and able to reduce the potential of having a critical labor shortage in the near future.

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CHAPTER 12

Implementing Technology Education

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Education is as old as human existence and provides the foundation for the continuation of human activities. It is a universal of all societies. This universality was communicated by Bowsher (1989) when he wrote, "Few human endeavors involve as many people as education. Learning, both formal and informal, takes place in every country, city, town, and village and in every language" (p. 13). Education is a fundamental activity for all people and, therefore, it is important that it meets its primary mission, which is to prepare citizens to participate fully in society.

In early cultures, formal education was designed for the elite, while job preparation was relegated to formal and informal apprenticeship programs. As the world became more complex, so did the educational needs of people. Schools were opened for the growing numbers and diversity of students, and the curriculum was expanded to include subjects beyond the traditional liberal arts. In order to address the needs of the newly developed industrialized society, practical and utilitarian subjects such as agriculture, industrial arts, home economics, physical education, and drivers education were offered in many schools.

As a society emerges into a new age, old orders crumble and new ways of thinking, reacting, and conducting business emerge. This change has been expedited by global communication and transportation systems that evolved on the shoulders of computer electronics. Furthermore, this transition of technological systems has caused great stress on societal institutions. Koska and Romano (1988) described the situation as follows: "We are living in exciting times. Not a day goes by without reference to America's declining industrial base, loss of worldwide competitiveness, or our sorry education systems" (p. 14). Schools are under severe pressure today to restructure and meet the needs of a population that must participate in the new information age. Criticism, such as that voiced in a recent Motorola (n.d.) publication is common. It suggested that "a crisis exists in American kindergartner-through-12th grade (K-12) education, and the situation is getting worse. . . . The American work force is rapidly losing its world-class status. The obsolescence of the American school system is a major factor in that potential decline" (p. 1).

A number of people agree with Reed (1994), who stated that schools must guard against offering a curriculum that prepares students to be "the road kill on the information highway." One movement to improve the curriculum involves implementing technology education experiences for all students. In order for implementation to occur, however, there must be a change in attitudes, values, and performances of teachers, administrators, and students. This chapter will address the process of change associated with implementing a new technology education program.

FUNDAMENTALS OF CHANGE

Change can be described as altering an existing situation, structure, or mode of behavior. Piersol (1993) spoke on the anxiety of change when he stated, "The only person that welcomes change is a wet baby." This may be a bit harsh, but is it safe to agree with March (1992) who wrote, "People look to the future with hope, but they prefer the way things were done in the past" (p. 20). These observations suggest that large numbers of people do not look forward to change, with its accompanying need to develop new knowledge and expertise. In order to overcome this common human trait, the people who lead change efforts must understand the three essential elements of change: team, vision, and plan.

Team

Schools are generally structured under the belief that we live in a competitive society. Combs (1979) suggested, however, that this view of a competitive society is almost totally false. He suggested that "we live in the most cooperative, interdependent society the world has ever known" (p. 15). A recently produced motivational plaque described the importance of the team. It quoted Henry Ford as saying the following: "Coming together is a beginning; keeping together is progress; working together is success" (Teamwork, 1993).

Educational leaders are starting to realize that education is not a competitive, personal effort. It requires a team that includes the students, teachers, school administrators, parents, and community. Similarly, educational change involves teamwork. Implementing technology education requires two team efforts: curriculum development and curriculum implementation. The curriculum development team plans and structures the technology education program. Team members develop the scope and sequence for the area of study, establish goals and objectives, identify content, suggest student activities, and indicate appropriate program and student evaluation procedures. The composition of the curriculum development team will differ according to whether it is a local or state effort. A local technology education curriculum development team should include technology education teachers, guidance personnel, school or district curriculum specialists, and administrators. State-level technology education curriculum teams should include classroom teachers, teacher educators, state technology education consultants, representatives of the state technology education association, school administrators, and guidance personnel. Business and industry members can add a valuable perspective to the team, if they have a general view of education and realize that technology education is not designed to develop specific job skills.

Team members can bring a variety of talents and views to a curriculum development and implementation project. Classroom teachers understand what students can do and what motivates them to learn. Teacher educators can bring a national or global view of technology education. The state consultant can articulate the changes in state curriculum rules that are needed to implement the curriculum. State association representatives can provide insight into ways to communicate information about the curriculum development effort to the teachers in the field. Local school administrators and guidance personnel can explain scheduling and budget constraints that the curriculum must accommodate.

Each person in the team views technology education from a specific, and sometimes narrow, perspective. The "they" pronoun is often used to excuse lack of progress in implementing curriculum change. Statements made in public about the failure to change the curriculum include the following: "They (the administrators) won't buy me the equipment I need;" "They (the teachers) are teaching outdated content and won't change;" and, "They (the guidance personnel) only send me low ability students." The team can only make progress when each member recognizes that he or she is part of both the problem and the solution. Assigning blame for past actions is counterproductive in addressing curriculum issues.

It is essential for people staffing the teams to realize that the skills required to develop the curriculum are uniquely different from those required to teach the curriculum. Curriculum development is an analytical task requiring people to identify appropriate content from a vast body of technological knowledge and then to organize it into coherent units. Teaching, on the other hand, is a performing art that is built on a scientific base. Effective teachers use psychological and sociological knowledge to select appropriate strategies to present the identified content, prepare appropriate instructional materials, and present them in an exciting, refreshing way, much like an actor on stage. A good teacher may not be a good curriculum writer and, likewise, a good curriculum writer may not be a good teacher.

The curriculum team must be a group that is willing to work towards a common goal and must exhibit the following characteristics:

> *Mutual respect*: Each member's ideas and contributions are seen as essential to the group's success.
>
> *Support compromise*: Each member is willing to adjust to the consensus of the group.
>
> *Shared vision*: Each member is committed to curriculum change.
>
> *Group goals*: Each member is willing to work for group goals even if it means giving up personal position, laboratory space, or personal recognition.
>
> *Differentiated roles*: Each member supports the need for the team to play to individual strengths by identifying members to accept specific roles (facilitator, detail person, visionary, spokesperson, etc.).
>
> *Dedicated*: Each member is willing to accept program revitalization as a prime professional goal. (Wright, 1989, Section IX)

Curriculum change that is meaningful can only happen when a significant number of people believe technology education is important for students preparing to participate in 21st century life. Each member of the team must be willing to direct his or her time and talent to the task and to place group goals ahead of personal agendas and recognition.

Vision

"In the face of uncertainty and ambiguity permeating much of our lives, one thing is for sure: the future is out there" (Patterson, 1993, p. 38). "There is no such thing as 'status quo' in this complex, fast paced world. One is either moving forward or falling behind" (Eli Lilly and Company, 1988, p. 1). "Education must shift into the future tense" (Toffler, 1970, p. 367). These statements send a strong message that technology education leaders should not try to drive the educational vehicle into the future using the rear-view mirror. The curriculum must be developed without significant regard to what teachers know, can do, or like to do. Furthermore, it cannot be based on present-day local conditions or student interests. Curriculum development requires a vision of what is needed for students to participate actively in the society of the future.

A clear vision statement helps the curriculum team stay on track and keeps it from being distracted by the latest fad or government funded initiative. Each move the group makes should be made in terms of its contribution to reaching the vision. A good vision statement should be the following:

> *Futuristic*: The vision addresses long-term (five- to ten-year) growth.
>
> *Philosophically sound*: The vision is based on a study of the most contemporary movements in the field.
>
> *Personnel and facility free*: The vision is not based on specific expertise or competence of the faculty or on the physical facility at the institution.
>
> *Issue based*: The vision addresses fundamental issues (a curriculum for the 21st Century) (Wright, 1989, Section IX).

A vision statement that meets these rules appeared in *America's Academic Future.* It stated the following:

> We envision a society in which the public regards science, mathematics, and technology as relevant to their personal lives. Engineers, mathematicians, and scientists are perceived by the public as vital to society, and scientific and technological literacy are well defined. Engineering, mathematics, and science concepts and contributions are communicated effectively to all segments of society, principally through formal instruction in our schools and universities but also through informal, out-of-classroom educational opportunities and programs. The public can apply the principles of science to the solution of everyday problems. (Lohmann & Stacy, 1992, p. 6)

An example of a vision statement for technology education that meets the above rules was developed for the State of Indiana. It reads as follows: "All students in Indiana will be able to apply their knowledge in appropriately designing, selecting, and using current and future technologies and in assessing their impacts" (Indiana ITE Curriculum Committee, 1992, p. 1).

Throughout a team's work, political hurdles must be recognized and addressed. Within the group, there will be people with varying amounts of power to implement curriculum change. If team members use their power to solidify personal rather than group positions, the curriculum development effort will travel a difficult path. A vision statement, however, can be the catalyst to cause people to direct their power away from personal agendas and toward a commonly held goal.

Plan

Steller (1983) stated, "Educators have come to recognize that very little happens by itself in an organization, other than disorder and friction. Success in education is almost never the result of sheer luck. It is, instead, the outcome of careful planning" (p. 68). A vision statement for technology education gives general direction and defines the overall task. However, the team is doomed to failure if it tries to do everything at once. The overall task must be divided into manageable subdivisions using an action plan. A good plan must be the following:

> *Problem centered*: The plan carefully defines and delimits the problem.
> *Focused*: The plan addresses fundamental issues first (the curriculum) and specific problems (enrollment, funding, etc.) second.
> *Logical*: The plan addresses issues in a logical sequence: (1) Philosophical foundations, (2) Content or essential elements, (3) Sequencing content and courses, (4) Strategies for presenting content, (5) Implementation, and (6) Follow-up and revision.
> *Detailed*: The plan has general goals that are divided into specific tasks.
> *Attainable*: The plan is attainable in a reasonable length of time with the human and financial resources available. (Wright, 1989, Section IX)

Additionally, the plan should identify the following:

> *Resources*: The plan establishes the sources and types of human and financial resources needed.
> *Responsibilities*: The plan identifies individual responsibilities for completing each task.
> *Deadlines*: The plan has specific deadlines for each general goal and specific task. (Wright, 1989, Section IX)

Action plans can be developed in a number of different formats. A sample plan for developing and implementing a statewide technology education program is shown in Figure 12–1. An action plan provides direction for the curriculum development team and indicates the time constraints it faces. The plan also gives progress benchmarks that allow the team to experience success as it completes one task and moves to the next.

AN ACTION PLAN TO IMPROVE
TECHNOLOGY EDUCATION

PHASE ONE—Developing a Philosophical Foundation

I. TASKS AND DEADLINES

A. Develop a rationale for technology education.

B. Develop a definition for:
   1. Technology
   2. Industry
   3. Technology education

C. Identify the curriculum organizers for a contemporary technology education program.

D. Develop the first issue of **Curriculum Update** to acquaint all industrial arts teachers of contemporary curriculum issues and directions for technology education.

II. COMPLETION DEADLINE: May 1, 19xx.

PHASE TWO – Curriculum Development

I. TASKS AND DEADLINES

A. Determine the structure of the curriculum, courses to be offered, course descriptions, and the sequence of the courses by January 1, 19xx.

B. Appoint subcommittees, with classroom teacher, supervisor, and teacher educator representation, to develop a series of courses in each major area of the curriculum by January 1, 19xx.

C. Develop a format for the curriculum guides by January 1, 19xx.

D. Introduce curriculum subcommittees to the general curriculum philosophy and content outlines by January 15, 19xx.

E. Subcommittees develop or adopt general content structures and representative activities by May 15, 19xx.

F. Subcommittees develop draft course guides for each course in the curriculum by September 1, 19xx.

G. Edit and duplicate curriculum guides by April 1, 19xx.

H. Develop four issues of **Curriculum Update** - #2 (October, 15, 19xx), #3 (March 1, 19xx), #4 (October 15, 19xx), and #5 (March 1, 19xx) to keep the profession informed about the curriculum changes.

II. COMPLETION DEADLINE: February 1, 19xx.

Figure 12-1: A sample action plan for developing and implementing a technology education curriculum.

PHASE THREE – Pilot Implementation

I. TASKS AND DEADLINES

A. Identify five pilot schools for the curriculum by September 1, 19xx.

B. Petition the Department of Education to have the courses included in the Administrative Rules by September 15, 19xx.

C. Provide in-service workshops for the pilot school teachers, guidance counselors, and principals by June 1, 19xx.

D. Monitor and evaluate the curriculum in the pilot schools.

E. Provide the pilot schools with consulting services related to implementing the curriculum.

F. Conduct state-wide in-service programs to acquaint school personnel with the new curriculum.

G. Develop a **Course Description** booklet by May 1, 19xx.

H. Develop a booklet for guidance personnel by May 1, 19xx.

I. Develop **Curriculum Update** #6 (October, 19xx).

II. COMPLETION DEADLINE: June 1, 19xx.

PHASE FOUR – Curriculum Revision

I. TASKS AND DEADLINES

A. Establish an editing team for the curriculum by September 1, 19xx.

B. Revise the curriculum guides using the results of the pilot tests by April 1, 19xx.

C. Publish the revised guides by June 1, 19xx.

D. Suggest a curriculum guide distribution policy by June 1, 19xx.

E. Revise the **Course Description** booklet by April 1, 19xx.

II. COMPLETION DEADLINE: August 1, 19xx.

PHASE FIVE - State-Wide Implementation

I. ONGOING TASKS

A. Actively solicit support for change from classroom teachers, administrators, and state Department of Education personnel.

B. Seek schools to serve as pilot implementation centers for initial state-wide implementation of the curriculum by December 1, 19xx.

C. Conduct in-service training for pilot implementation school personnel by August 1, 19xx.

Figure 12-1—cont'd.

D. Solicit schools to adopt the curriculum by January 1, 19xx and thereafter.

E. Provide in-service training for teachers from implementing schools by August 1, 19xx and thereafter.

II. COMPLETION DEADLINE: Continuing.

PHASE SIX - Implementation Support

I. TASKS AND DEADLINES

A. Encourage state universities to participate in revising the industrial arts teacher certification pattern by September 15, 19xx.

B. Develop a **Program Guide** to describe the technology curriculum philosophy and rationale by January 15, 19xx.

C. Develop an Equipment Guide for the curriculum by January 15, 19xx.

D. Develop a public relations program to include:

(1) a general public relations booklet by March 15, 19xx.

(2) a student public relations flyer by October 1, 19xx.

(3) a set of video tapes, by October 1, 19xx, which:

(a) explains the rationale and structure for technology education.
(b) presents an administrator's view of technology education.
(c) presents technology education as it relates to students.
(d) encourages high school students to become technology teachers.

E. Arrange to have printed and video material duplicated by November 1, 19xx.

F. Work with the state Technology Education Association to produce a print, film and video resource guide.

G. Prepare an in-service workshop director's manual by May 1, 19xx.

H. Publish periodic issues of the **Curriculum Update**.

I. Provide local school district implementation support as required.

J. Work with the Department of Education to interface the Technology Education Curriculum with the Tech Prep initiative.

II. COMPLETION DEADLINE: May 1, 19xx and thereafter.

Figure 12-1—cont'd.

Finally, the plan allows the team to communicate a game plan to those who are interested in the new curriculum.

MISSION AND GOALS

"Plan the work and work the plan" is a phrase frequently used in industry. This phrase suggests that change involves more than just planning—it requires the energies of people implementing change to focus on the tasks outlined in the plan. The first step in implementing a technology education program is to develop a clear and concise mission statement and a set of goals.

The emphasis of technology education will vary depending on the way in which the team defines key terms, therefore, an initial task involves defining technology and technology education. The International Technology Education Association's (ITEA) position paper (Wright & Lauda, 1993) defined technology as "a body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment" (p. 3). In a subsequent ITEA publication, Wright, Israel, and Lauda (1993) defined technology education as "an educational program that helps people develop an understanding and competence in developing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions" (p. 5).

Another curriculum development task is to describe the relationship between technology education and vocational education. People who use a historical perspective may select the traditional vocational-technical (voc-tech) emphasis that has been a characteristic of many industrial arts programs. This approach uses vocational programs and their content to identify the specific content for their general education counterpart—industrial arts. Many technology educators are more interested in a futuristic science-technology (sci-tech) emphasis. This approach builds programs based upon the relationships between science and technology, with science describing the natural world and technology explaining the human-made world. This sci-tech emphasis supports the position that all academic subjects (language arts, social science, mathematics, science, technology, etc.) contribute to general and pre-occupational education in the same way. The subjects provide a broad view of society, build a base of citizen and consumer responsibilities, and develop the knowledge necessary to select a career path and pursue occupational education.

Finally, curriculum developers must address the content versus process question that is fundamental to many current education change efforts (American Association for the Advancement of Science, 1993; National Council of Teachers of Mathematics, 1989; National Curriculum Council, 1990; National Science Teachers Association, 1992). There are at least two conflicting missions for technology education in the United States: (a) a process-centered mission that helps students use the design process as a way to solve problems, and (b) a content-centered mission that helps students develop an understanding of the techniques and processes used to produce technological products and systems. The first mission has its roots in the design and technology curriculum of England. It is supported in its pure form by a limited number of technology educators, notably those most closely associated with the philosophy promulgated by *TIES* magazine. The second mission is based primarily on the philosophy undergirding the Jackson's Mill curriculum theory project. This is the most prevalent approach being practiced in the United States. A third approach that is starting to evolve uses the common technological actions of developing, producing, using, and assessing. This technique integrates both designing and processing. (See Chapter 7 of this yearbook for more specific details on this approach.)

An example of a set of mission and goal statements that uses the developing-producing-using-assessing approach for technology education is as follows:

> *Technology Education*: An action-based program for all students to learn how to design, produce, use, and assess the impacts of products and services that extend the human potential to improve and control the natural and human-made environment.
>
> *Mission of technology education*: To develop, within students, the ability to participate actively in designing, producing, selecting, using, and assessing technology with concern for the individual, society, and environment.
>
> *Fundamental objectives*: Each student will understand technology as a system in the global context by developing an ability to:
>
> 1. Design technological products and services.
> 2. Use tools, machines, materials, and energy to produce products and services.
> 3. Select appropriate technology to solve problems and meet opportunities.
> 4. Appropriately use technology to extend human potential to improve and control our environment.
> 5. Assess the impacts of technology on individuals, society, and the environment.
> 6. Use appropriate personal and interpersonal skills to participate in a technological society. (Indiana ITE Curriculum Committee, 1992, pp. 1–2)

Carefully developed mission and goal statements describe what technology education is and what it is not. These statements define the area of study and present the evaluation criteria that all curriculum development activities must meet.

DEVELOPING THE CURRICULUM

Once the philosophical foundation, which includes statements of the mission and goals, is set, the curriculum is developed. There are a number of ways to describe the curriculum. Glatthorn (1987) suggested that it is "the plans made for guiding learning in the schools, usually represented in retrievable documents . . . and the implementation of those plans in the classroom . . . " (p. 1). This broad definition indicates that curriculum determines what to teach and also includes the actual teaching—it is planning and action, content and method. Curriculum development under this definition determines the scope and sequence of the study, establishes plans for each course in the program, and identifies the actions to be used in teaching each course.

Scope And Sequence

The definition and objectives for technology education describe the area of study. Curriculum developers must establish a scope and sequence for the study of technology before students can engage in the subject. The scope establishes the content boundaries for the subject, while sequence organizes the concepts and processes of the field into logical arrangements for teaching. Scope and sequence can be applied to the entire area of study or to a course within the area. An overall scope and sequence plan, as described by the National Science Teachers Association (1992), allows curriculum developers to arrange education experiences so that the key concepts of the field are appropriately sequenced, organized in a manageable scope, and coordinated within and between disciplines.

An example of scope and sequence can be found in the design and technology (D&T) curriculum developed for England and Wales. This program requires that all students will study D&T during each year of schooling. The scope of the content is established by four major design process activities and four themes.

The design activities and their accompanying objectives were described by the National Curriculum Council (1990) as follows:

- Identifying Needs and Opportunities
- "Pupils should be able to identify and state clearly needs and opportunities for design and technological activities through investigations of the

contexts: home, school, recreation, community, business and industry" (p. 3).

- Generating a Design
  "Pupils should be able to generate a design specification, explore ideas to produce a design proposal and develop it into a realistic, appropriate and achievable design" (p. 7).
- Planning and Making
  "Pupils should be able to make artifacts, systems and environments, preparing and working to a plan and identifying, managing and using appropriate resources, including knowledge and processes" (p. 11).
- Evaluating
  "Pupils should be able to develop, communicate and act upon an evaluation of the processes, products and effects of their design and technological activities and of those of others, including those from other times and cultures" (p. 15).

Within the boundaries of the design activities, students engage in four major themes: (a) developing and using artifacts, systems, and environments; (b) working with materials; (c) developing and communicating ideas; and (d) satisfying needs and addressing opportunities (National Curriculum Council, 1990). The program is sequenced so that content is presented through themes and projects in the primary school, and as a separate subject in the secondary school. The activities are structured so that students progress from simple to complex tasks as they move through their 11 years of required schooling. At early levels, teachers use familiar contexts such as home and community for the simple design problems. At advanced levels, pupils explore more complex contexts while they are "given more opportunities to identify their own tasks for activity, and should use their knowledge and skills to make products which are more complex, or satisfy more demanding needs" (National Curriculum Council, 1990, p. 19). The scope and sequence plan takes final form in a series of courses for students to take as they study technology education. A program model for technology education that shows scope and sequence is shown in Figure 12–2.

Writing The Curriculum

Most schooling is based on mastery of facts. The National Science Teachers Association (NSTA) (1992, p. 13) supported this view in its quotation from Dickens', *Hard Times*: "Now what I want is, Facts. Teach

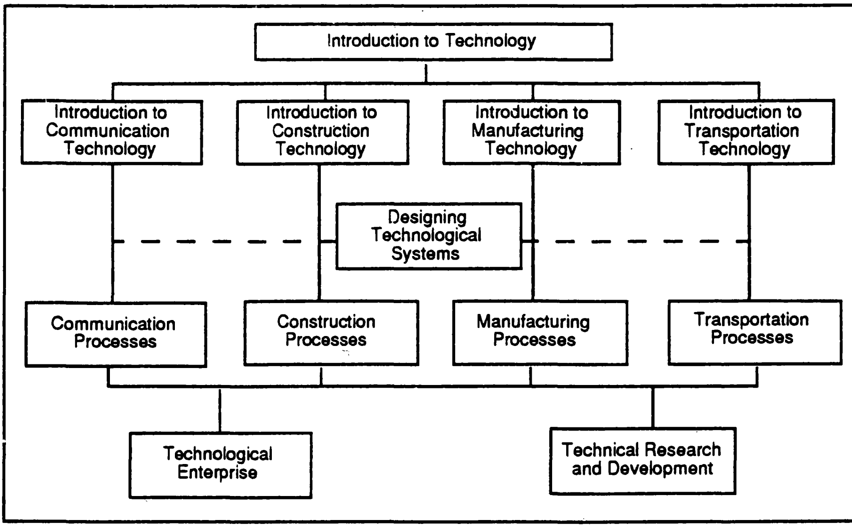

Figure 12-2: Sample course sequence (Wright, 1991).

these boys and girls nothing but Facts." The NSTA authors suggested that a new movement in education is underway and they described the movement as "less is more" (p. 14). This approach suggests that by covering fewer topics, students develop a deeper understanding for a subject. It recognizes that teaching fewer concepts, and teaching them well, allows students to apply their knowledge when addressing new problems and opportunities.

In meeting the challenge to develop and implement conceptual-based courses, Glatthorn (1987) suggested that curriculum developers use the following eight-step process:

1. Stake out the territory by setting boundaries for the course or program.
2. Develop a constituency that will support the course or program.
3. Build a knowledge base by broadening the understanding about students, course content and processes, and research.
4. Block in the units by establishing the number, focus, sequence, and length of the units to be included in the course.
5. Develop a unit-planning guide that communicates the unit format and approach for those who are developing the unit.
6. Use the unit-planning guide to develop quality learning experiences.

7. Develop the unit or course tests.

8. Package the product.

When writing the curriculum, the curriculum development team documents what learning experiences are planned for the students as they complete a technology education class. A well-written document with good activities will help close the gap between the taught curriculum (what the teacher does in the classroom) and the learned curriculum (what the students learn in the classroom).

PREPARING TEACHERS FOR NEW CURRICULUMS

New curricular and instructional approaches require a new set of teacher skills. Technology education requires that teachers have three unique experiences to complement the general or liberal arts studies required of all university graduates. They must be able to *know* technology, *do* technology, and *teach* technology. Specifically, teachers must be able to do the following:

1. Understand technology and the processes used to develop, produce, use, and assess technological artifacts, systems, and environment. (Know technology.)

2. Use tools, materials, energy, and information to develop, produce, use, and assess technological artifacts, systems, and environment. (Do technology.)

3. Identify, organize, and conduct appropriate learning experiences so that students can develop, produce, use, and assess technological artifacts, systems, and environment. (Teach technology.)

These new demands require both a new type of technology teacher education program and a significant in-service program for teachers already in the field.

Pre-service Teacher Education

Most technology teacher education programs have their heritage in industrial arts teacher education. Changing from industrial arts to technology education requires that new courses be added or old courses be revised in order to add the *know* technology element to the program. Students need to develop an ability to do the following: (a) describe technology as a product of human volition; (b) demonstrate an understanding of technology as product, process, and organization; (c) explain why technology is developed, (d) describe the impacts of technological actions; and (e) describe the relationships between science and technology, and technology as a system. In addition, traditional, narrowly focused technical courses need to be replaced with broad-based courses that are designed to develop general abilities and knowledge in students. The courses need to enlarge their single focus on such areas as materials processing or drafting skills and address the developing-producing-using-assessing actions of all technologies. This particular requirement provides a unique challenge as teacher education programs continue to shrink in numbers and, in most cases, use courses from other programs, such as industrial or engineering technology, to present the *do* technology component. These engineering-type programs, because of their mission, focus on depth of understanding rather than on the breadth needed by technology education teachers. Finally, the lecture-demonstrate focus of methods courses needs to be revised to prepare students to use a greater variety of individual and group activities. Future technology teachers need extensive training in the following areas: (a) organizing, managing, and evaluating group activities; (b) using open-ended design and problem-solving activities; and (c) integrating instruction with other disciplines. An example of a National Council for Accreditation of Teacher Education (NCATE) accredited technology teacher education program that addresses the *know-do-teach* needs of technology teachers is shown in Figure 12–3.

In-service Teacher Education

In most states, industrial arts teachers are licensed to teach technology education. In order for these teachers to be successful technology educators, they should receive significant in-service training provided by universities, state technology education associations, or state departments of education. Good industrial arts teachers generally have the requisite technical (do technology) skills and possess many of the required pedagogical (teach technology) skills. They need an opportunity, however, to develop the following: (a) a solid introduction to the philosophy of technology education; (b) an understanding that technology education is not focused solely on do technology; (c) an understanding of technology and the ways it is developed, produced, used, and assessed; and (d) an ability to use teaching techniques beyond the lecture-demonstration-individual project approach.

In-service programs can be offered as continuing experiences over a school year or as an intensive summer program. Programs will be more

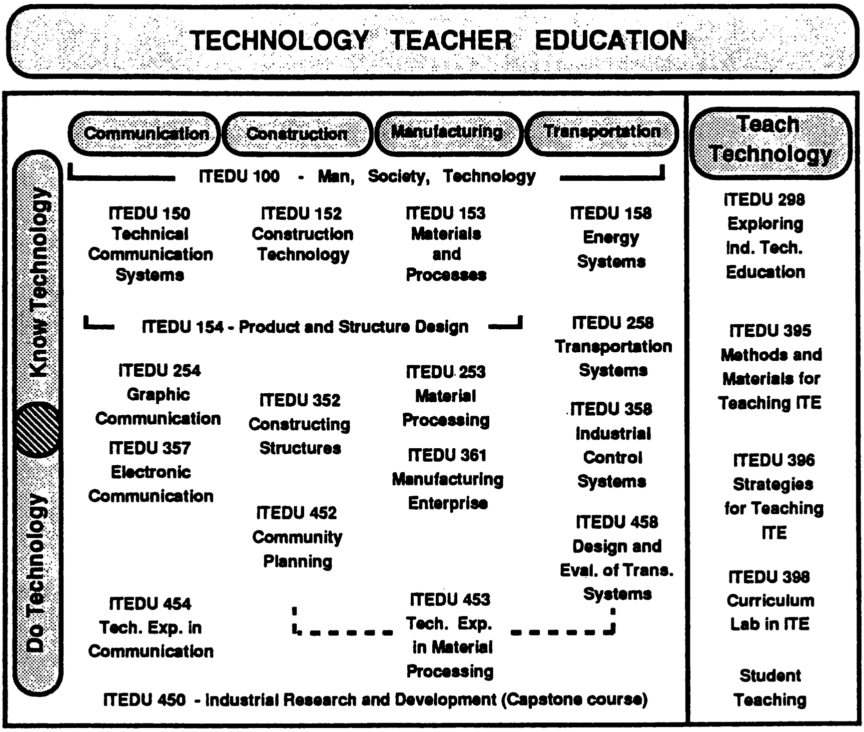

Figure 12-3: Ball State University's technology teacher education curriculum.

readily accepted by teachers if the in-service experiences are presented by successful secondary school technology teachers, rather than by university or state department of education personnel. A format and sequence for offering an in-service technology education program may vary considerably due to the time available, needs of the participants, and available funding, equipment, and facilities. One state's in-service program recommends that the following topics be included in all technology education in-service programs:

1. An overview of the in-service schedule (agenda)
2. Philosophy of the program
3. Rationale/structure of the proposed course work
4. Overview of the individual courses (grades 6–12)
5. Format of the curriculum guides

TOPIC (Approx. Time)	DESCRIPTION
Introductory Session (4 hours)	Cover program goals and structure, the purpose of individual classes, distribute guides, etc.
Review Individual Courses (8 hours)	Cover each of the 18 courses in greater detail.
Work Sessions (22 hours)	Time for workshop participants to develop instructional plans and classroom materials.
Laboratory Sessions (18 hours)	Development of laboratory teaching materials for each course.
Related Sessions (8 hours)	Covering resources, details of implementation, recruiting, etc.

Figure 12-4: A sample agenda for an in-service workshop. (Indiana ITE Curriculum Committee, 1990, p. 7)

6. Lesson planning procedures
7. Instructional media/resources
8. Facility planning
9. Equipment, supplies, and related materials
10. Guidance and counseling
11. School and community involvement
12. Recruitment activities (Indiana ITE Curriculum Committee, 1990, p. 2)

This in-service program has been developed to follow a 60-hour format that includes a series of information sessions, individual work periods, and laboratory experiences. A recommended agenda for a typical workshop that covers these elements is shown in Figure 12–4.

Technology education is a new curriculum area with its own philosophy and content. Teachers trained in a different curriculum cannot be expected to be successful technology educators without the benefit of in-service programs. The inability to provide this training will create a situation in which the likelihood of teacher failure is high, resulting in students receiving a poor technology education experience.

EVALUATION

All curriculum efforts should be subjected to rigorous evaluation. Jordan (1981) suggested that "evaluation is the process of making meaning out of experience and converting experience into meaningful behavior, which results in better learning programs" (p. v). This statement implies that we can evaluate to determine what was gained from an experience or change the experience to improve its performance. The first type of evaluation measures student achievement and the latter type is a program evaluation that should be an integral part of curriculum development and implementation activities.

The overall program should be evaluated against societal goals and expectations. The back-to-basics movement of the 1970s focused education on operational level functional skills. This focus led to the development of minimum proficiency testing and program evaluation (Marzano, Pickering, & McTighe, 1993). The quest for economic growth and a continuing supply of world class workers caused society to reassess the low-level aspirations characterized by the back to basics movement. A new array of higher order competencies has been developed by many groups (National Education Goals Panel, 1992; Secretary's Commission on Achieving Necessary Skills, 1991). A typical list was presented in the Secretary's Commission on Achieving Necessary Skills (1991) report entitled, *What Work Requires of Schools*. It suggested that each student should possess the following three-part foundation and five competencies:

FOUNDATION

Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.

Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons.

Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.

COMPETENCIES

Resources: Identifies, organizes, plans, and allocates resources.

Interpersonal: Works with others.

Information: Acquires and uses information.

Systems: Understands complex inter-relationships.

Technology: Works with a variety of technologies (p. vii).

The first program evaluation task is to measure the program's mission, vision, and objectives against national or state goals. Curriculum organization, structure, and effectiveness must be evaluated, using both formative and summative evaluation techniques. The curriculum is developed in draft form and implemented in selected pilot sites. During the pilot teaching phase, the content and activities are evaluated to determine their appropriateness for grade level and student interests. It is important that the evaluation be structured to measure the curriculum's ability to meet broad general education goals. Technology education, like all other disciplines, should meet the needs of the school population, regardless of the students' specific career aspirations. Evaluating technology education on the needs of specific local industries or other special interest groups would be as inappropriate as it would be to evaluate foreign language, science, or art programs on similar criteria. The evaluation phase provides the foundation for action. The results should be summarized, analyzed, and used for curriculum modification and revision.

SUMMARY

Many people believe that American schools are at risk for failing to meet the challenges of the new millennium. A recent publication (Indiana Curriculum Advisory Council, 1991) summarized the concern as follows:

> Leadership with vision, shared by the citizens of all [American] communities, is needed now. The vision called for is a new type of schooling which ensures that all children have an equal opportunity to learn to the highest level of their ability. (p. 19)

Technology education programs that are developed by a team with an appropriate vision and a workable plan can succeed in contributing to this vision. They can contribute to a school that is seen from the student's point of view as

> a place where I can learn easily and successfully what I need and want to know. Where I am treated with respect and where I will be constantly urged, coached, and supported to be as good as I can be and not constantly compared to others. Where I can take risks with ideas and be allowed to fail without being judged a failure. (Indiana Curriculum Advisory Council, 1991, p. 19)

This is the type of school and type of education that all parents want for their children and one that professional educators should be committed to delivering.

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CHAPTER **13**

Instructional Strategies For Technology Education

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The role and importance of instructional strategies for use in the classroom and laboratory have remained rather constant throughout the history of American education. In many cases these strategies have been without curricular boundaries, since those utilized by one subject matter area have often been applicable to several other subject matter areas. During the decades of the 1980's and 1990's, however, there appears to have been a surge of identifiable instructional strategies that were applicable specifically to technology education. This chapter will provide a brief overview of some of the more prominent instructional strategies that have surfaced during this time period. In order to gain a more comprehensive understanding of instructional strategies, the reader is strongly encouraged to conduct additional research in each of the topics covered in this chapter.

The purpose of this chapter is to provide the reader with an overview of the different instructional strategies that can be used by the contemporary technology education teacher while not endorsing one or more of the instructional strategies as being better than the others. The teacher must decide which instructional strategy is best for a given situation. Specifically, after reading this chapter one should be able to do the following:

1. Identify and define terms including instructional strategies, methods of teaching, delivery systems, and approaches to teaching.
2. Identify how higher order thinking skills relate to technology education instructional strategies.
3. Identify various learning theories used to increase student motivation.

4. Select different approaches to teaching technology education.
5. Select different delivery systems used to teach technology education.
6. Identify specific areas of research needed to be conducted in the future in the area of instructional strategies.

INTRODUCTION

Technology education has continued to develop and be defined over the past 15 to 20 years. During this time period, a clearer definition of technology education and its supporting content have been identified and developed. Along with the changing content, a plan must be developed to transmit the new knowledge, skills, and attitudes effectively to the students. It would be a mistake to assume that the new and updated technology education curriculum could be taught using the old, very traditional teaching methods. Years ago three teaching modes were dominant in the field: lecture, demonstration, and project methods. Today, contemporary technology education teachers are using a variety of procedures and strategies to complement the content that is being covered in their programs in the best way.

The technology education teacher must employ a wide variety of teaching methods to be an effective classroom teacher. The teacher's role has changed considerably in the past 25 years from being one of a dispenser of facts and information to being one of a manager or a facilitator of learning (Kemp & Schwaller, 1988). The contemporary technology education teacher needs about 50% of his/her educational preparation to develop content, and another 50% to develop teaching strategies. It is important, therefore, that the technology education teacher has an in-depth knowledge of a variety of teaching strategies.

Several key terms must first be defined in order to identify the most appropriate way to teach technology education. The first of these terms is *instructional strategies*, which is often referred to as teaching methods. Instructional strategies are used to describe all of the elements that comprise the teaching/learning process. The way material is presented, which is known as the delivery system, is certainly also very important. The delivery system, however, is just one part of the total teaching/learning process. Instructional strategies must also include consideration for learning theory, student motivation, approaches used to teach the content of technology education, the use of higher order thinking skills, and teaching in the different domains of knowledge.

DEFINING TEACHING APPROACHES

As the technology education teacher begins to plan and develop her/his teaching strategy and style, certain *approaches* to teaching begin to emerge. These approaches may be considered pathways or styles of teaching, or ways the technology education content can be viewed or managed. Approaches help the technology education teacher to instruct from a specific point of view and also help both teacher and student to meet many of the overall goals of technology education. The teacher can select one or more approaches to teaching, including using an interdisciplinary approach, a systems approach, a social/cultural/environmental impacts approach, a conceptual approach, and a futuring approach. If the technology educator emphasizes the systems approach, for example, the content would be constantly related to how it fits into various systems models being promulgated in the literature. If the technology education teacher deals with the content using a conceptual approach, then concepts rather then specific technologies would be emphasized throughout the course. Approaches, therefore, are defined as broad and encompassing styles or pathways of teaching that relate to the overall goals of technology education.

DEFINING DELIVERY SYSTEMS

Delivery systems are defined as the actual methods the technology education teacher uses to present content. A delivery system, therefore, is the method or way in which technology education content is conveyed, transferred, or presented to the student (Kemp & Schwaller, 1988). The most common type of delivery system is the lecture, while other examples may include but are not limited to demonstrations, the project method, use of media, group discussions, and problem solving.

STUDENTS' NEEDS AND MOTIVATION

The technology education teacher may employ a number of techniques to motivate students in the classroom. Years ago most classroom motivation was achieved by extrinsic means such as discipline, grading, and reports to parents. In today's educational setting, classroom motivation must come from intrinsic means, that is, students must be motivated from within rather than from some outside source. Today's classrooms are designed to be much more student directed rather than teacher directed.

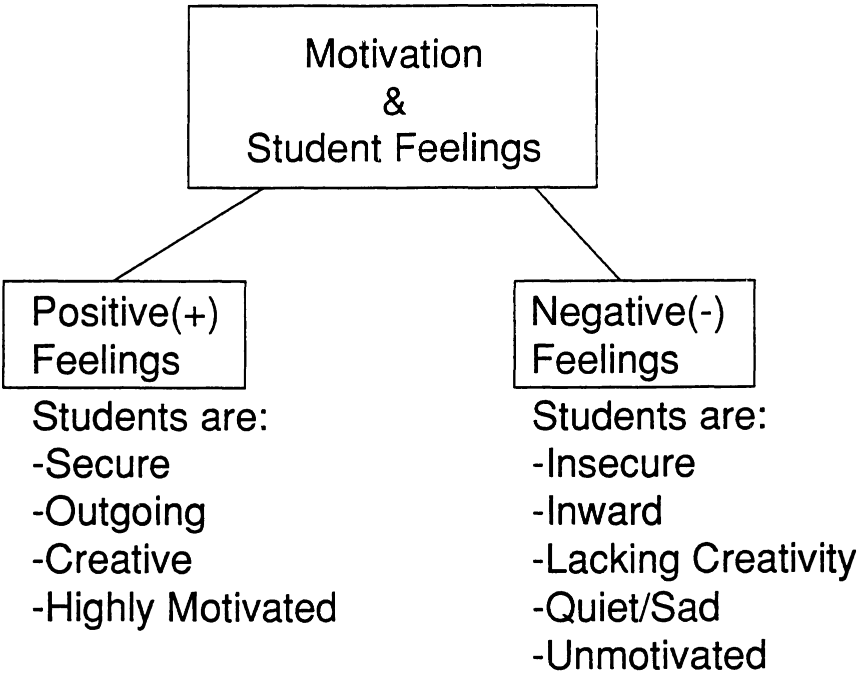

Figure 13-1: Motivation in the classroom is directly related to how a student feels.

Classroom motivation can best be accomplished by relating the classroom style and instructional strategies to the students' needs. The contemporary technology education teacher must be sensitive to the needs of the students as these needs relate to the technology content. If students feel good about themselves, if they feel part of the learning process, and if they feel they are a significant part of the learning environment, then their motivation seems to increase. Students' motivation for learning is tied directly to their needs, which are defined as conditions that reflect and are associated with feelings of well-being. The conditions of well-being tend to direct the motivational patterns of each student. Figure 13–1 graphically depicts words that describe students who are positive about themselves. Positive thinking students are generally more secure, outgoing, creative, happy, and highly motivated as compared to less positive-thinking students. Students who have negative feelings about themselves are generally more insecure, inward, noncreative, quiet or sad, and usually display less motivation when compared to more positive students.

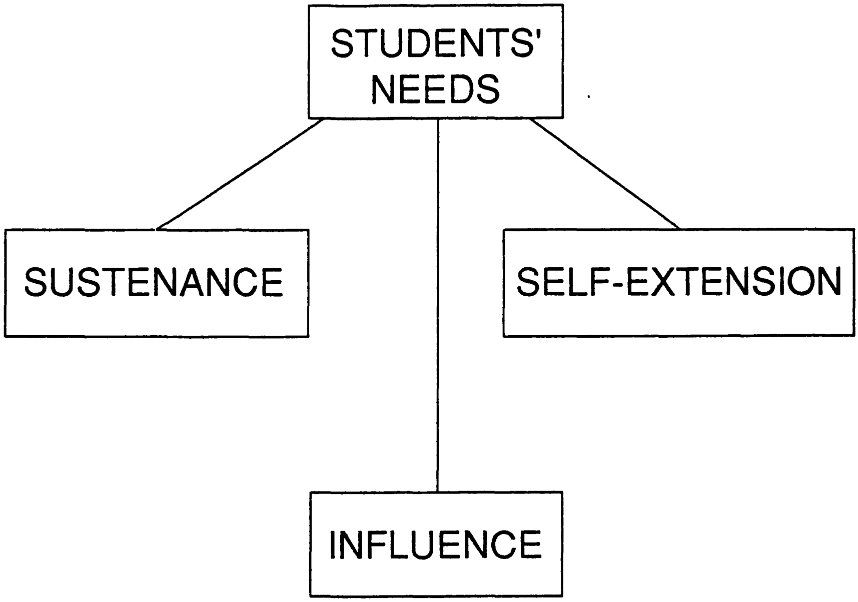

Figure 13-2: Students' needs can be categorized into three types.

Students' needs can be subdivided into three major types: sustenance, influence, and self-extension. These three types of needs are shown in Figure 13–2.

Sustenance comprises all those needs that are essential to a person's own self-maintenance and well-being. The student is typically receiving or accepting conditions which help meet his/her specific needs (the receiving end). People or existing conditions have a tendency to control or direct sustenance needs. These needs include food, sleep, rest, comfort, and group approval. If sustenance needs are not met, the student may develop negative feelings and have lower motivation within the technology education classroom and laboratory. If sustenance needs are met, then the student will experience higher motivational patterns. Although the technology education teacher does not have direct control over such areas as rest, sleep, and food, it is important to remember that the family or home environment often has a direct influence on the motivational patterns of the student. Understanding this influence goes a long way in helping to interpret a student's motivational patterns. If a student is not getting proper amounts of rest or if the student does not have the proper diet, then motivation in the classroom may be hampered.

The technology education teacher also has the responsibility to make sure that each student feels she/he is a significant member of the group or class. The teacher must be constantly aware of situations in which one or more students may become separated by the group or other class members. When students feel that other students don't like them or when students feel that other students are ridiculing them, then their classroom motivation will be seriously affected.

The second basic need is called influence, which is defined as developing control toward other people. The student can generally control conditions that help meet these needs, so in this situation the student is considered on the projecting end (not on the receiving end). Students have much more control of influence needs as compared to sustenance needs.

All students have a need for being influential in their lives. Words that help define influence needs include status, significance, position, expertise, importance, worth, valuable contribution, competence, and comfort giving. If a student does not feel competent, important, or significant, negative feelings will usually result and motivation will be reduced. If a student has position, importance, expertise, and status, positive feelings will generally exist and motivation will increase. In the classroom, the technology educator can have a direct impact on a student's influence needs. The teacher, for example, can do the following to enhance students' influence needs: (a) make sure the students feel they are learning material that is both important and relevant; (b) encourage students to help other students in the learning process; (c) provide students with as many successes as possible in the classroom; and (d) never ridicule a student's technological competence in front of other students. A teacher who is able to make students feel significant and competent in the technology education classroom will go a long way in producing positive motivational patterns.

The third basic need is called self-extension. Self-extension means being creative, internalizing, reflecting on ideas, and being able to self-actualize. In a traditional classroom setting, time for creativity, reflection, internalizing, and self-actualizing is not provided very often. Every student, however, must be provided time to meet this very important basic need. The technology educator must plan and organize his/her classroom and instructional strategies to allow for self-extension to be met. The technology education classroom will become much more open-ended, less prescriptive, and more creative when conditions for self-extension are present. A teacher who provides students with a prescribed solution to a problem is providing a much less motivational experience than a teacher who allows students the opportunity to solve problems based upon their past experiences. Students get excited about their class when given time to be creative and self-actualizing.

The contemporary technology education teacher can have an enormous influence on whether students have positive or negative feelings in a classroom or laboratory setting. Negative feelings resulting in less motivation are present when a teacher belittles students, makes them feel dumb or stupid, downgrades students, becomes too prescriptive, discourages success, and thinks of all students as being slow learners. Students exhibit positive feelings and greater motivation when they receive positive encouragement, are allowed to display creativity, are made to feel important and competent, and are allowed to assist other students in the learning process. It is quite evident, therefore, that the technology education teacher can have a direct influence on the motivational patterns of students.

HIGHER ORDER THINKING SKILLS

Learning styles and basic theory must play an important role when selecting various instructional strategies. Many learning theories have been proposed for use in technology education. Educational theorists such as Jerome Bruner, Frederick Bonser, and John Dewey have proposed learning theories that are commonly associated with learning styles such as learning by doing, experiential learning, and hands-on learning.

Bloom's Taxonomy (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) is one learning model that can be used when selecting different approaches and delivery systems for use in technology education. Bloom's Taxonomy suggested that all learning occurs in three domains: cognitive, affective, and psychomotor (1956). All three domains play a significant role when teaching technology education. Cognitive learning involves the development of intellectual skills and abilities. Affective learning involves attitudes, feelings, and values that are developed within the student (Krathwohl, Bloom, & Masia, 1964), while psychomotor learning deals primarily with the development of muscular and motor skills. Figure 13–3 illustrates the interrelatedness of the three domains.

In the technology education classroom most, but not all, information that is learned begins in the cognitive domain. Once the information is learned, it can be transferred to the psychomotor domain and/or the affective domain. This means that before most affective or psychomotor learning occurs, cognitive information must be learned. There is also a relationship between the psychomotor and affective domains—one domain will aid the other in its development. This means that psychomotor skills developed in the technology education laboratory may assist in the development of desirable attributes, attitudes, and feelings in the affective domain. If a student in manufacturing technology has a solid foundation in welding skills,

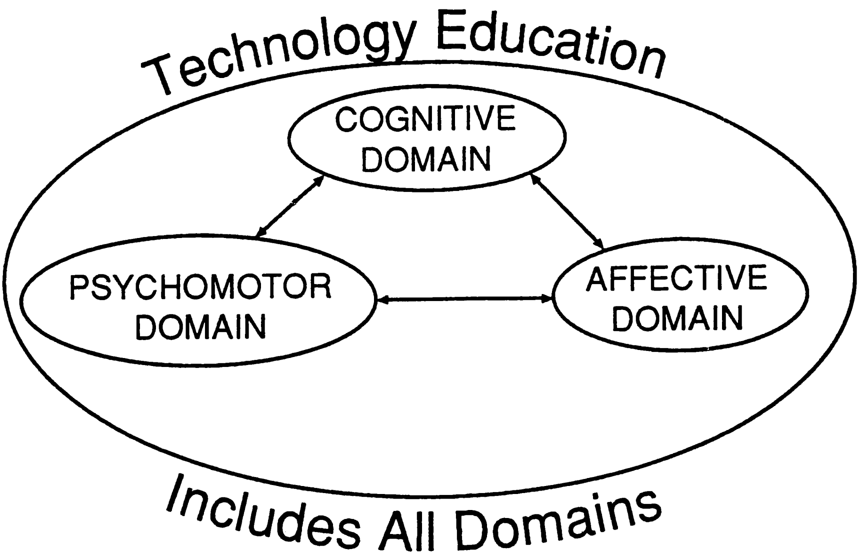

Figure 13-3: The three domains of Bloom's taxonomy.

for example, these skills may enhance the student's attitude about the importance of quality in the process of parts fabrication. Attitudes, feelings, and values learned in the affective domain may also directly effect the quality of work performed within the psychomotor domain. If a student has developed strong and valid attitudes about the design of a new type of transportation system, for example, it may very well effect the quality of work performed within the transportation laboratory.

In traditional classroom and laboratory settings, the psychomotor domain may have been overemphasized at the expense of the other domains. In the contemporary technology education classroom and laboratory, however, the technology teacher is constantly aware of the importance of all three domains. Depending upon the exact technological content being covered, learning should be emphasized in all of the domains. If concepts are being taught, the cognitive domain may be emphasized. If social/cultural and environmental impacts are being discussed, the affective domain may be emphasized. If processes and tools are to be addressed, the psychomotor domain may be emphasized. In today's technology education classroom and laboratory, learning in all three domains must be carefully planned by the teacher.

In addition to Bloom's cognitive, affective, and psychomotor domains, each domain has sub-levels that must be considered by the teacher. Higher order thinking skills, referred to by the acronym as HOTS (Scanlin, 1992),

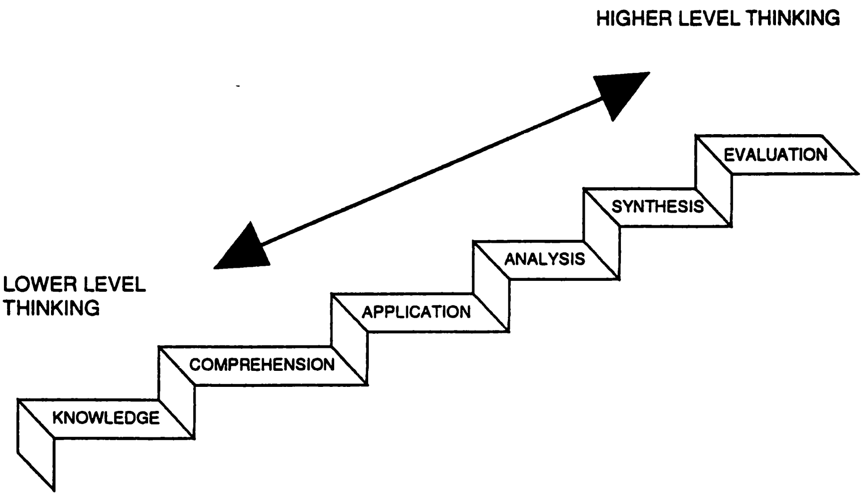

Figure 13-4: The six levels of learning in the cognitive domain.

are related to the various sublevels of learning within the cognitive domain. Figure 13–4 identifies the six major levels of learning in the cognitive domain. Descriptions of each level are provided in the paragraphs that follow.

1. Knowledge is the level that emphasizes remembering, either by recall or by recognition, and is considered the lowest level of learning. It is necessary to learn at this level in order to get to the next higher level which is called comprehension. A good example of learning at the knowledge level can be seen when students memorize the formula for calculating horsepower, which is as follows:

$$\text{Horsepower} = \frac{\text{Torque} \times \text{RPM}}{5252}$$

   The level of teaching and thus the evaluation for this information are designed so the students need only to recall or recognize the formula for calculating horsepower.

2. Comprehension is the level that emphasizes the transfer of information into more understandable forms. It includes restating the material in words other than those learned at the knowledge level. Using the previous example for calculating horsepower, the student must not only know the horsepower formula but must know it well enough to restate the formula into a more understandable form.

3. Application is defined as applying or using information to arrive at a solution to a problem. Students typically are required to bring together information learned at the knowledge and comprehension levels to solve problems. Using the previous example for calculating horsepower, the student must be able to calculate horsepower when torque and revolutions per minute (RPM) are given.

4. Analysis is the level that involves the taking apart of a concept, idea, or process. The emphasis at the analysis level is to show how the many parts of a system make up the whole. Using the example for calculating horsepower, the student must be able to analyze the formula by knowing the relationships that exist among torque, horsepower, the constant number 5252, and RPM. This analysis requires that the student have an understanding of the purpose of using the constant 5252, be able to explain why the RPM and torque are multiplied together, and be able to define the condition of an engine that has been tested for horsepower.

5. Synthesis entails the creative meshing of elements. Synthesis learning requires the use of learned information at all previous levels. Using the example for calculating horsepower, the student must now be able to compile information derived from the formula or to develop creative ways in which more horsepower could be derived from an engine.

6. Evaluation involves making decisions on controversial topics and substantiating these decisions with sound reasoning. Using the example for calculating horsepower, the student must be able to appraise or judge the condition of the engine based upon the horsepower readings.

In the publication entitled *The Minnesota Plan for Industrial Technology Education* (Minnesota Department of Education, 1985), various verbs typically associated with each of the six levels in the cognitive domain were identified. These verbs are shown in Figure 13–5. Traditional classroom teaching and learning styles tend to concentrate on the lower order thinking skills such as knowledge, comprehension, and application, while technology education challenges teachers to set up learning environments so that students work with higher order thinking skills that include analysis, synthesis, and evaluation.

All technology education teachers should have as their goal the selection of instructional strategies that create learning situations to bring students up to the higher levels of learning. Students will not be working to their maximum potential if the goal is for them to work only up to the comprehension or application levels.

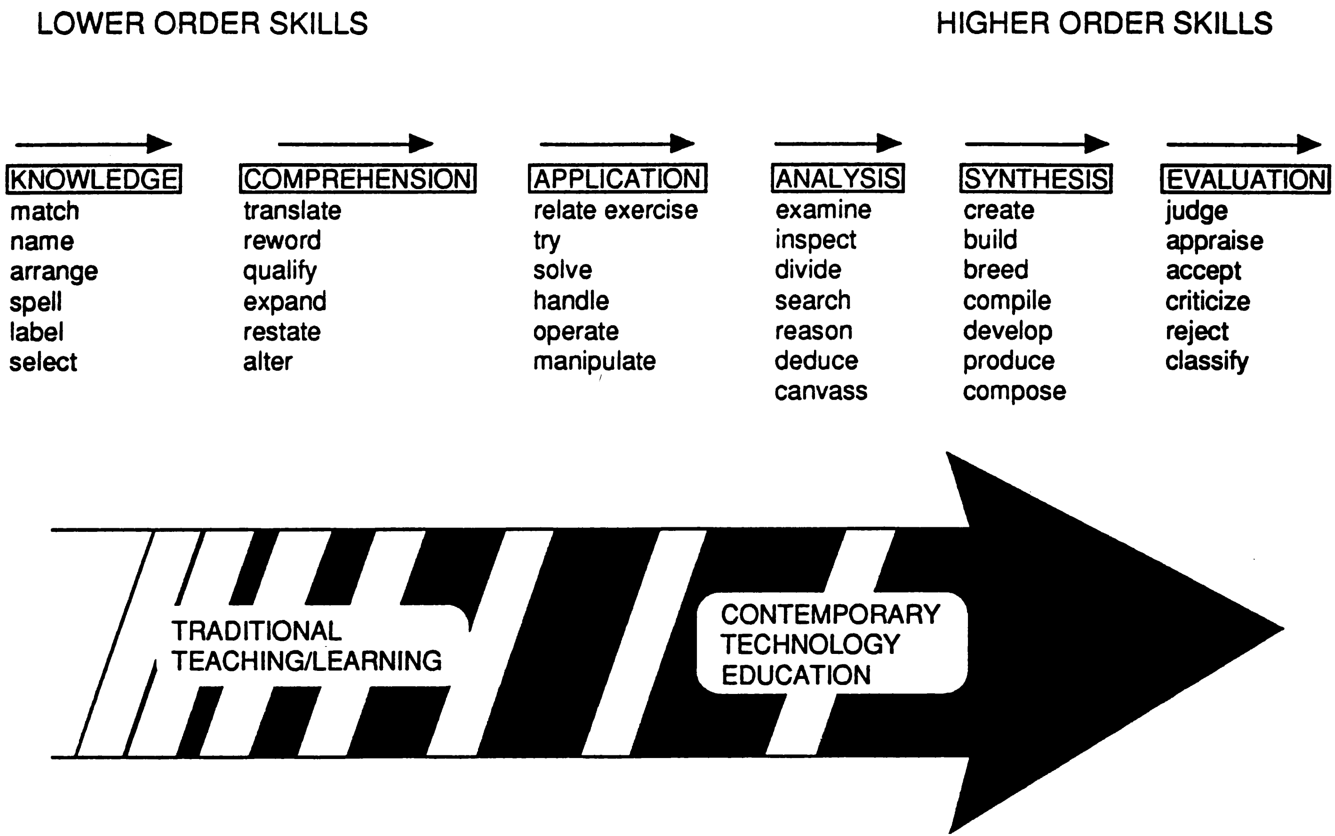

Figure 13-5: Verbs used to describe each of the six levels in the cognitive domain.

APPROACHES USED IN TEACHING TECHNOLOGY EDUCATION

There are many approaches that have been proven to be successful when teaching technology education. The approach(es) selected will be determined by the technology content to be learned, the course or unit objectives to be achieved, and the method utilized by the technology education teacher to facilitate the learning process.

Systems Approach

The systems approach has been used in technology education for several years. It suggests that most of the technology being taught in the classroom relates to the study of systems. Teaching from a systems approach provides the teacher with the flexibility to teach the total concept of technology education, and it facilitates students' learning about technology as a whole, rather than just the individual segments or parts that make up the whole of technology. DeVore (1980) supported the use of the systems approach when he stated that "the study of technology has been approached too frequently by studying the parts without reference to the whole" (p. 243).

There are several technological system models being used today. An operational model used in several current technology textbooks is illustrated in Figure 13–6 (Schwaller, 1989). This system includes inputs, processes, resources, outputs and impacts, feedback systems, and a compare and adjust component. The input is defined as the command or objective of any technological system. The process is defined as the technical concept or principle

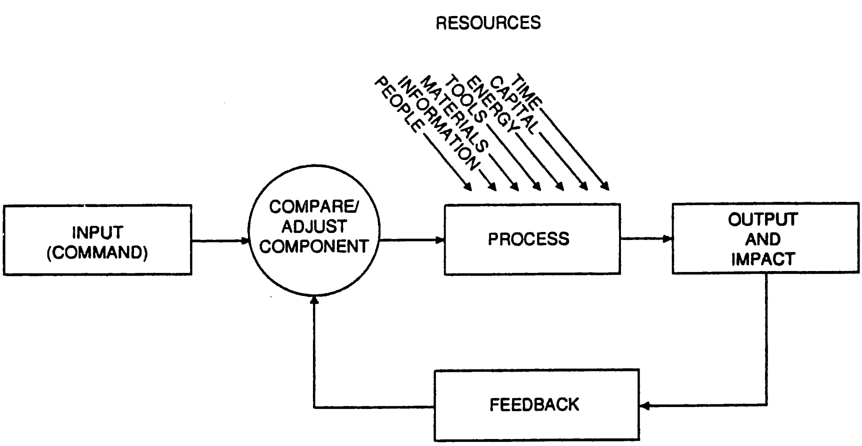

Figure 13-6: All technologies can be studied by using the systems model.

used to accomplish the command or objective. The process occurs based upon various resources including people, information, materials, tools, energy, capital, and time. The output is the end result. Along with the output are the positive and negative impacts (social, cultural, environmental, etc.). The feedback is a monitoring system, also called the control system.

The advantages of using the systems approach in the technology education classroom and laboratory include the following: (a) specific technologies can be taught as they relate to solving problems in each of the technological areas in the study of technology education; (b) each activity in the technology education classroom can have meaning to a larger social/cultural problem; (c) students can constantly see the impacts, both positive and negative, of each technological system; (d) students can see how each specific technology relates to the overall technological system; and (e) students can be encouraged to think in the analysis and synthesis levels of the cognitive domain.

Interdisciplinary Approach

The interdisciplinary approach allows the technology education teacher to draw effectively upon other disciplines when teaching technology education. Gilberti (1992) suggested that interdisciplinary teaching should include a study of science, technology, and society as a whole. Zuga (1988) suggested that rarely does a discipline exist and get presented as subject matter in a pure form. Teaching about technology requires knowledge from mathematics, physics, history, literature, and many other disciplines. The study of design in technology education, for example, may rely on various principles of physics and mathematics. The study of transportation and energy relies heavily on mathematics, physics, social science, and historical information. Several familiar examples of interdisciplinary approaches include Principles of Technology, The Richmond Plan (Cochran, 1970), and The Orchestrated Systems (Yoho, 1967).

There are several advantages gained by using an interdisciplinary approach, including the following: (a) technology education is considered general education, and general education is interdisciplinary in nature; (b) cooperation among other teachers is enhanced; (c) the student can see the content from a broader view and perspective; and (d) technology education becomes much more meaningful because society as a whole is interdisciplinary (Edmison, 1992a).

Social/Cultural/Environmental Approach

The social/cultural/environmental approach involves teaching technology education as the content relates to our society, culture, and environment.

The technology education teacher addresses technology by identifying problems within these three areas. All technology is designed to meet some specific, perceived human need so when the technology is developed and utilized, it has various impacts on society, its culture, and its environment. Approaching the technology education curriculum from this perspective helps students see the purposes, reasons, and impacts of each technological area being studied.

There are several advantages to using the social/cultural/environmental approach which include the following: (a) students develop an awareness of how humankind interacts with technology; (b) technological impacts can easily be studied; (c) students demonstrate improvement in their decision-making capability about technology; (d) students have an opportunity to see how technology interrelates with social institutions such as the family, religion, industry, government, and education; (e) students are able to view technology from a broad perspective rather than just the perspective of tools and processes (Wright, 1988); and (f) students often learn at the synthesis and evaluation levels.

Conceptual Approach

The study of technology is very broad and is influenced by rapid changes in technology. It is extremely difficult to update the technical side of the technology education curriculum continually. When the conceptual approach is used, the technology education teacher identifies and teaches various concepts and principles about the technological system being studied. Specific facts are only used to support the concepts and principles. In the study of solar energy, for example, it would be difficult to teach about each new selective coating being invented for the surface of a solar thermal collector because each year a better selective coating is placed on the market. The concept of selective coatings, however, including their purpose and applicability, is very important. The technology education teacher should teach the concepts related to selective coatings rather than each new specific technology that is developed and used as a selective coating.

The advantages of using the conceptual approach include the following: (a) concepts remain more constant while specific technologies are always changing; (b) concepts can easily be related to other technological areas; and (c) the overall curriculum content becomes easier to manage and more time is available to conduct additional learning activities. There are concepts of compression ratios or air/fuel ratios, for instance, that are related to gasoline, diesel, and turbine engines. Rather than teaching these concepts in each engine unit (teaching them three times), it would be recommended that the concepts be taught only once in the beginning of the course.

Teaching from the conceptual approach causes the technology teacher to reorganize the content into identifiable concepts, which are much easier to manage than specific technological content.

Futuring Approach

Studying the future has become an effective approach to teaching in technology education. This approach is often called "futuring." Futuring refers to a technique of forecasting that is used to define and solve future-oriented problems (Thomas, 1981). All technology education programs and curricula should include some study as to how technology will be used in the future. The futuring approach addresses this need by incorporating problem solving, trend analysis, and inductive and deductive reasoning. Teamwork, research, and communication skills are also commonly required when engaged in futuring activities.

There are three types of futuring techniques used in the technology education classroom. These techniques include trend analysis, scenario development, and cross-impact analysis (Wright, 1992). Trend analysis involves the study and extrapolation of present trends into the future. In the area of transportation technology, for instance, data can be collected on how the price of a gallon of gasoline has increased over the past 50 years. Using this data and the average increase in price for each year of the study, trend analysis can be used to project the percentage of increase into the next two decades. Trend analysis, therefore, can help to project the future price of gasoline.

Scenario development involves the creation and description of alternative futures based on different assumptions about society. An example of scenario development would be to have students define the impacts of constructing additional nuclear energy power plants. The students would develop a scenario about possible impacts from social, economic, environmental, technological, and political points of view. The projected picture of the future would be based upon various assumptions about how our society views the increased use of nuclear energy to supply increased amounts of electricity to a population that already uses too much energy.

Cross-impact analysis involves the creation of a matrix of variables along horizontal and vertical axes. Students are asked to determine how the impact on one variable will have other variables. Cross-impact analysis, for example, could be used to determine the impacts of mass communication in our society. Variables on the vertical axis might include social impacts, cultural impacts, economic impacts, and political impacts. These variables would then be cross referenced with a set of variables on the horizontal axis, which might include family, work, and leisure. An analysis could be made, therefore, as to how mass communication affects the family, the work place, and leisure time activities from a social, environmental, political, or environmental point of view. The cross-impact matrix method causes the students to analyze each variable in terms of another set of given variables. This type of futuring is much more prescriptive in that variables are often determined by the technology education teacher, while the impacts are determined by the students.

The futuring approach has several advantages that include the following: (a) students are able to participate in problem-solving activities that address realistic problems for the future; (b) students learn to work in the area of self-extension and creativity; (c) students learn group cooperation and increase their interpersonal skills; (d) students think and learn using higher level thinking skills such as synthesis and evaluation; and (e) students are often asked to be creative and to extend their thinking beyond reality. This type of learning aids the self-extension needs addressed earlier in the chapter.

DELIVERY SYSTEMS USED IN TEACHING TECHNOLOGY EDUCATION

There are many different delivery systems that have proven to be successful when teaching technology education. The delivery system chosen will be determined by the exact technological content to be covered, the course or unit objectives, and the approaches selected by the technology education teacher to facilitate the learning process. Three of the more popular delivery systems used in technology education classes today are (a) cooperative and group interaction; (b) models, games, and simulation; and (c) inquiry learning.

Cooperative and Group Interaction

One of the more popular delivery systems used in teaching technology education is called cooperative or group learning. Henak (1988) stated that cooperative group interaction and learning techniques are "classroom activities designed to capitalize on the human desire to talk and share ideas. Personal interaction is an activity in which two or more people are actively involved in exchanging ideas" (p. 143). Students have a sense of belonging and self-actualization because of their ideas being received and respected (Henak, 1988). The outcomes of group learning also then become directly related to the sustenance and influence needs as described earlier in this chapter.

Group interaction type learning becomes a very valuable delivery system with the increased emphasis in technology education on exploring values and affective attitudes about society, technology, and the environment. In each of the technological areas of communications, construction, manufacturing, and transportation various issues can be addressed. Discussions could occur, for instance, on the impacts of mass communication on society, the economic impacts of a sluggish construction industry, the increasing importance of ethics in manufacturing, and/or the social impacts of building a new airport in a city. The possibilities for cooperative and group interaction activities in the technology education classroom are endless.

There are a variety of group interaction techniques such as questioning (open and closed ended), discussions, debates, brainstorming, seminars, committees, and role playing. These delivery systems enhance the ability of the technology education teacher to be a more effective teacher. The advantages to using group interaction and learning in the technology education classroom include the following: (a) students learn at higher levels of thinking and develop critical thinking skills in the areas of synthesis and evaluation in the cognitive domain; (b) students develop values and attitudes (affective domain) about important technology education topics; (c) students have increased motivation and their social responsibility is also increased; and (d) students learn in much the same way as do other people who work in business, industry, government, and other agencies.

Models, Games, and Simulation

Models, games, and simulation are delivery systems that involve specially designed activities in the technology education classroom. These systems provide opportunities to practice various components of life itself by providing a set of players, a set of allowable actions, a segment of time, and a framework within which the action takes place (Johnson, 1985). Orlich (1985) defined these types of delivery systems as an artificial problem, event, situation or object that duplicates reality through technology, but removes the possibility of injury or risk to students. Models, games, and simulation provide representations of what exist or what might exist in a physical or social interaction. As technology is becoming more and more complex, there will be a greater need for incorporating models, games, and simulation in the technology education classroom. Common examples of these types of delivery systems include computer modeling, conducting a grievance hearing in a manufacturing organization, simulating a manufacturing system, and organizing a debate about a nuclear energy.

There are various advantages to using models, games, and simulation as delivery systems in the technology education classroom. The advantages include the following: (a) learning occurs in higher levels of the cognitive and affective domains; (b) students are able to learn analytical processes more easily; (c) complex problems and systems are reduced to manageable elements for learning; and (d) the learner is more motivated (Edmison, 1992b).

Inquiry Learning

Inquiry learning is defined as an investigative delivery system and is often called an experimental, discovery, testing, or problem solving system. This type of delivery system effectively encourages students to develop critical thinking skills. Inquiry learning focuses on the process of investigating and explaining unusual phenomena, mostly in a technological sense (Daiber, 1988). Problems and situations that are strictly technological can be developed. Troubleshooting a computer, testing a specific type of furnace or engine, diagnosing a computer program for manufacturing, and designing a levitated vehicle for transportation are all possible inquiry type of activities. Social/environmental/technological problems can also be used in inquiry learning and could involve such activities as designing a mass transportation system for a specific purpose or designing a new solar photovoltaic system for use in a specific application. The key consideration in selecting any inquiry type activity is that the activity must be an actual problem in society, rather than a problem that is fabricated, fake, or artificial.

The inquiry delivery system model generally has several phases. One such model often used during the inquiry process includes the following steps:

- Define and state the exact problem
- Verify the problem
- Gather necessary data
- Formulate a possible solution
- Assess the solution
- Restructure the solution to best solve the problem

Using an inquiry delivery system has many advantages, including the following: (a) students learn at the highest level of evaluation in the cognitive domain; (b) students acquire process skills of observing, collecting and organizing data, identifying and controlling variables, and formulating hypotheses; (c) students develop logical thinking skills by following an organized method of inquiry; (d) students learn to work independently and as a group in order to solve a problem; and (e) the technology teacher is truly a facilitator of learning in this type of delivery system.

Issues And Future Considerations

The instructional approaches and delivery systems covered in this chapter describe a few of the many instructional strategies that may be used in technology education. Each type of approach and delivery system has various components and styles that should be further studied before using them in classroom and laboratory settings. The general theme of each of the instructional strategies, however, tends to focus on the following: (a) it brings students to higher level thinking skills and develops critical thinking patterns; (b) it makes the teacher much more of a facilitator of learning rather than a person who prescribes facts and technical bits of information; (c) it gets the students to think in terms of their values, attitudes, and feelings about technology and its impacts on society; and (d) it moves away from teaching processes and tools to providing the students a much more Gestalt or broad view of technology.

A great deal of research on improving instructional strategies within the technology education classroom has been completed, but additional research still needs to be conducted. As the content of technology education continues to change and improve, new and innovative instructional strategies must be researched, tested, and incorporated for improved learning effectiveness. Future instructional strategies will continue to focus on critical thinking skills, more value and affective orientation, development of interpersonal skills, and improved retention by the students. Future research in the area of instructional strategies will center on finding ways to improve retention at the higher levels of thinking, improving evaluation and accountability in the affective domains of learning, and improving the motivation of the learner in the technology education classroom and laboratory.

Research is drastically needed in the area of pre-service programs for improving instructional strategies for technology teacher education programs. Presently, many states have too many schools that still teach the use of traditional instructional strategies, emphasize the teacher as a fact giver (not a facilitator), emphasize only psychomotor skills that focus on the project method, and teach only tools and processes to their upcoming technology education teachers. In addition, numerous technology teacher education programs have not coordinated their efforts with the traditional College of Education units. In order for a technology education student teacher to be effective, many of the instructional strategies mentioned in this chapter must be tried and experienced during the student teaching experience. Too often future technology education student teachers are placed in traditional programs for their student teaching experience. In order for technology education to become a viable and much sought after discipline, these instructional practices must change to become future oriented.

Another area that needs serious attention is the provision of updated instructional strategies to existing technology education teachers in the field. Teachers who try to make the change to technology education often think the only change needed is that of content, but both content and instructional strategies must change to become an effective technology education program. A wide variety of in-service programs must be made available to existing technology teachers to help them update and improve their instructional strategies. If this can be done effectively over the next several years, existing and future technology education teachers will play an important role in the secondary school curriculum.

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CHAPTER **14**

Undergraduate And Graduate Technology Education

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Dramatic changes are currently underway in undergraduate and graduate technology education programs. Educational reform, economic factors, and the transformation from industrial arts to technology education are only a few of the elements affecting the design, structure, and implementation of college level programs in technology education. The results of such dramatic changes have caused some programs to accept challenges for restructuring while others have faced the possibility of elimination. Current and future programs at the graduate and undergraduate levels consist of a diverse mix of experiences designed to prepare and upgrade technology education teachers and to develop human resource talent into technology education leadership roles. An additional but unrealized goal of graduate programs is to develop and advance a quality research agenda for technology education (Waetjen, 1991; Johnson, 1993).

Recent trends show declines in the number of graduate and undergraduate technology education programs along with increased opportunities and interest in non-teaching technology degree programs that focus on business/industry careers. While such startling declines pose an immediate threat for some people in the profession, others have found new opportunities for research and experimentation with new paradigms for undergraduate and graduate technology education that embrace collaborative efforts with related areas such as science, mathematics, and applied disciplines.

RATIONALE FOR UNDERGRADUATE AND GRADUATE STUDIES IN TECHNOLOGY EDUCATION

The world we live in is increasingly affected by technology. National defense, the economy, and the very root of our democratic society are affected by the level of technological literacy of our citizens. The need to study technology is not under question. In fact, during the last few years there have been repeated calls for some form of technology education to be provided in our public schools (*Technology: A National Imperative*, 1988). A dilemma, however, must be resolved. Is technology a separate academic discipline with its own integrity and unique body of knowledge, or is it a field of study that has greater significance when integrated with other disciplines? It is the position of the authors of this chapter that technology as a discipline contains knowledge of value to all learners and as such, has integrity as an educational subject. As a discipline, however, its knowledge base adds value to other subjects such as mathematics and science by extending their understanding and application to the resolution of scientific principles. One example is the field of electrical engineering where principles of mathematics and science are applied with technological concepts to create engineering praxiological systems, concepts, and practices. A second example is medicine where physicians study the application of science principles to control human behavior and physical/bodily functions. Assuming that technology education has integrity and value as a separate discipline and can be structured for instructional purposes, one might ask, where in today's school curriculum does it belong?

Technology educators, most of whom were originally prepared to teach industrial arts or industrial technology education, have assumed the major responsibility for shaping the focus of technology education in the public schools. During the last two decades, elementary and secondary school programs, as well as college and university programs, have been in a transition from industrial arts to technology education. If a well articulated, coherent program for providing technological literacy for the citizens of our country is to be achieved, it seems reasonable that elementary and secondary schools must respond with programs in technology education that are supported by graduate and undergraduate programs in colleges and universities.

Unique Functions and Purposes of College-Level Programs

A major function of graduate and undergraduate programs in technology education is to supply teachers who are qualified to provide instruction in the elementary and secondary schools. A second and emerging function is to work with colleagues in other disciplines to develop the interdisciplinary role of technology education with such subjects like social studies, humanities, sciences, and mathematics. A third function of undergraduate and graduate programs in technology education is to provide opportunities for developing and implementing a research agenda for the advancement of knowledge and professional practice in technology education.

DEVELOPMENT OF GRADUATE AND UNDERGRADUATE DEGREE PROGRAMS

A precursor to the current degree programs in technology education came in the late 1800s in the form of manual training in the public schools (as a part of general education). Teachers were not supplied by degree programs, but were recruited from craftspersons in industry (Sotzin, 1961). The first professional courses for teachers of manual training were offered at Teachers College, New York which eventually led to a two-year major course in manual training, culminating in a college degree (Bennett, 1937, pp. 468–469). Buffer (1979) noted that the training of industrial arts teachers and teacher trainers progressed from the craftsperson level to pre-baccalaureate formal training programs in normal schools. This led to current baccalaureate, master's, and doctoral program structures. Currently, listed in the *Industrial Teacher Education Directory* (Dennis, 1992) are over 150 collegiate programs that show some affiliation with technology education.

The period following the Smith-Hughes Act of 1917 gave way to the expansion of industrial arts programs in public schools and consequently laid the ground work for the development of industrial arts (manual training) programs at teacher training institutions, alongside trade and industrial (T&I) education counterparts. When documenting the relationship that existed in the 1930s, Evans (1988) noted the following:

> In contrast to T&I teacher trainers, industrial arts (or manual training) teacher education faculty in the mid-1930's were much more numerous . . . the 160–180 higher education institutions involved in industrial arts teacher education made their own decisions about which persons were qualified to train industrial arts teachers and which would be employed. (p. 6)

The outbreak of World War II had a profound negative effect on growth and quality of industrial arts programs (and respective teacher education programs) but the post-war era witnessed a positive growth and development period (Martin & Luetkemeyer, 1979). Undergraduate and graduate programs in industrial arts flourished in the 1950s and provided the foundation for the development of the American Council on Industrial Arts Teacher Education (ACIATE) in 1950. (Note: This council is now known as the Council on Technology Teacher Education.) The 1950s also witnessed a period of intense curriculum reform as a result of the Russian launching of Sputnik (Martin & Luetkemeyer, 1979), and the ACIATE provided a forum for the discussion of teacher education issues. The reaction in the United States to the launching of Sputnik caused the promotion of many funding (public and private) opportunities that allowed for some of the most creative research and development efforts that the field of industrial arts has ever experienced. These efforts provided opportunities for articulation between graduate and undergraduate programs in industrial arts and the public schools. The growth and development of undergraduate and graduate industrial arts programs continued through the 1960s and 1970s, benefiting from additional funding from federal initiatives in career and vocational education.

William E. Warner and his graduate students at The Ohio State University are credited with being the first to use the term *technology* in association with the field in a paper entitled *A Curriculum to Reflect Technology* (1965). The paper was presented at the 1947 American Industrial Arts Association (AIAA) convention. Several years later, some of Warner's colleagues at The Ohio State University received a major grant to create a body of knowledge that focused on *Industrial Technology* as a discipline. The Industrial Arts Curriculum Project (IACP, 1966) defined industrial technology as a discipline and structured its body of knowledge that formed the basis for creating curriculum and instructional courses to teach about the person-made world much as science taught about the natural world. The use of the term *industrial* to modify technology was deliberate to focus one's study on *industry* and its technological applications rather than using the term alone so that one might conclude that it applied broadly to other disciplines such as medical technology. Many departments of industrial arts teacher education adopted industrial technology as their new designator. The non-teacher education options, however, appeared to gain greater growth and popularity among students and faculty particularly at the baccalaureate level. Therefore, the term industrial technology seems to be associated today more with non-teacher education programs.

As a result of a meeting of a group of graduate and post-graduate students at West Virginia University in the spring of 1970, the term *Technology Education* became a descriptor for the former Industrial Arts program (Lauda & McCrory, 1986). Several programs followed the lead of West Virginia University and changed their names as well to reflect a technology perspective. A decade or so later, the AIAA changed its name to the International Technology Education Association (ITEA) at about the same time that many state (education department) plans were also changing their emphases to reflect the term technology in favor of the term industrial arts. Colleges and universities have been slower to move in changing their names, as Volk (1993) noted that just over 30 programs listed in the *Industrial Teacher Education Directory* (Dennis, 1990) contained a technology education descriptor.

Along with the name change from industrial arts to technology education, many teacher education programs at the graduate and undergraduate levels are currently implementing structural changes to their respective programs to reflect technology teacher education. These changes coincide with educational reform changes that are also being implemented at colleges, universities, elementary, and secondary schools. Most changes involve a restructuring of curriculum, facilities, entrance and exit criteria, and upgrading of faculty, to name a few. LaPorte (1993) noted the tremendous diversity that currently characterizes the manner in which technology education teachers are prepared. This is often stimulated by the transition away from the preparation of industrial arts teachers to the implementation of technology teacher education programs. Such transformations have presented new challenges and opportunities for graduate level technology education to design and experiment with new models for implementing technology education as a part of their research agendas.

The decade of the 1980s witnessed an end to the growth of technology education programs in the elementary and secondary schools. Moreover, the number of institutions providing technology teacher education programs has been on a sharp decline and the number of graduates prepared to enter the field of teaching has correspondingly experienced a sharp decrease (Volk, 1993). Such declines can be attributed to factors such as a poor United States economy, public school and higher education (especially teacher education) reform movements, and an increased need from industry for graduates of non-teaching industrial technology programs. The economic viability of merging teacher education programs with non-teacher education programs has caused some confusion over the mission of technology teacher education when combined with non-teacher options.

PROGRAM IDENTIFICATION AND COMPARISONS

In addition to the confusion over the mission of technology education programs, there exists much diversity in how various undergraduate and graduate programs are articulated around the country. Different approaches to the implementation of technology education programs resulted from factors such as differences in philosophies, state standards, and respective university requirements in general, professional, and graduate studies. Furthermore, the "personality" of an institution may dictate the structure of the program. For example, institutions belonging to the Holmes Group (a consortium of so-called "research-oriented" universities) have different teacher education structures than those not embracing such a philosophical approach. Likewise, teacher preparation programs that coexist with industrial technology (non-teaching) programs have different structures than those programs that offer only technology teacher education.

Undergraduate Programs

Historically, the principal reason for undergraduate programs in technology education has been to prepare or contribute towards the preparation of teachers. Yet, a cursory examination of the professional and technical categories listed in the 1993–1994 *Industrial Teacher Education Directory* (Dennis, 1993), suggests that faculty are now engaged in a variety of professional activities focusing on the preparation of educational service providers and industrial technologists.

One such activity is the preparation of persons for business and industry in programs called industrial technology. Industrial technology graduates ordinarily do not take professional courses in education, but focus more on technical courses in areas like construction, manufacturing, communications, industrial management, industrial training (human resource development), and the like. While teachers and non-teachers may share a core set of courses (usually technical), industrial technology and teacher education programs are different and have different goals. LaPorte (1988) noted that there are fewer than ten "pure" technology teacher preparation programs (that is institutions whose sole purpose is the preparation of teachers) left.

If not administered carefully, industrial technology programs could be a deterrent to teacher education offerings. Volk (1993) observed, for example, the following general trends that have resulted from technology programs with a combined mission of teacher preparation and industry preparation:

> The decline in IA/TE graduates from universities which do not offer industrial technology program options was consistent with the national trends for all areas of teacher education . . . [however] the decline in IA/TE graduates from those universities offering industrial technology programs has been significantly greater than those that do not offer such options. (p. 54)

Another activity that technology teacher educators often find themselves engaged in at the expense of teacher preparation is the teaching of service courses. These courses are offered as a service to majors in areas such as special education/rehabilitation, occupational therapy, elementary education, science and/or math education, and other such areas. Ironically, this same practice was listed as a concern by Karnes and Lux (1961) in their chapter entitled "Graduate Study In Industrial Arts" as found in the 10th Yearbook of the American Council on Industrial Arts Teacher Education (p. 94).

Models for Teacher Preparation

While there is no one universally accepted model for teacher preparation, technology educators have generally accepted the three components of Nelson's (1962) model: general studies, professional education, and technical studies (see Horton, 1971; Clark, 1985; Helsel & Jones, 1986; Henak & Barella, 1986; Miller, 1991; LaPorte, 1993). Lux (1962) outlined the basic theoretical considerations for each of these components as follows: (a) "General education is a common experience and background for all educated persons" and "provides for the optimum development of knowledge in the areas of the sciences, humanities, communications, and personal maturity;" (b) [Technology Teacher Education] "is an integral part of the total field of teacher education [involving] laboratory and field experiences, theoretical and applied professional knowledge and skills integrated toward better teaching of subject matter and youth." (c) As it relates to technical studies or preparation, "the origin of subject matter is in technology [which is] in continuous change [contributing] to an advancing of technology" (p. 6). LaPorte (1993) extended the technical component of the model to include technical/technological, with the technical subcomponent including learning experiences that focus on the *how-to* and the technological subcomponent focusing on learning experiences dealing with the *about* of technology. When reviewing models for teacher preparation, it helps to examine both the conventional delivery systems and emerging structures for teacher education programs.

CONVENTIONAL UNDERGRADUATE TEACHER PREPARATION MODELS

Admission to technology education generally occurs after an applicant has completed at least one year of general or liberal studies and has earned a minimum grade point average (usually 2.25 to 2.50 on a 4.00 scale). If technology education is housed in a College of Education, then additional entrance criteria may be imposed and may include required minimums on measures such as the Pre-Professional Skills Test (PPST), English or math placement scores, ACT or SAT scores, etc. Furthermore, programs may require successful completion of a core of technical/technological courses prior to admission. In those institutions with engineering programs, many applicants may transfer from other programs within an institution (usually engineering or related fields) into technology education. In those programs with dual purposes—teacher education and industrial technology—fewer industrial technology majors transfer to teacher education than vice versa.

While there are currently models that allow for students to transfer from two-year institutions (Horton, 1971; Householder, 1992), these opportunities in technology teacher education have been unrealized until recently. New articulation agreements between two and four-year institutions are enabling some students in community colleges or technical schools to finish at least two years of a four-year program before transferring to a technology teacher education program.

Conventional models in technology teacher education typically find students progressing through a four-year baccalaureate program earning either a Bachelor of Science (B.S.) or a Bachelor of Arts (B.A.) degree with certification (by the state board of education) to teach. General or liberal studies are usually core requirements of the institution. Professional studies include such experiences as methods courses (which may be taught within technology education or by general professional educators), field or clinical experiences, laboratory and classroom management, foundations (history, sociology, psychology, ethics) of education, and student teaching. The technical/technological component is usually laboratory based and includes those courses unique to the discipline (or field) of technology. They include courses in technological problem solving, technology systems, and/or application of general studies (especially math and science) to technology.

Degree Structures and Certification

There is little consistency in the types of degrees that are awarded in technology teacher education institutions. For example, one finds by examining the *Industrial Teacher Education Directory* (Dennis, 1992), that the Bachelor of Science (B.S.) and Bachelor of Arts (B.A.) degrees are awarded almost equally. Oftentimes, these degrees will be "tagged" such as a Bachelor of Science in Education degree (B.S. in Ed.). Sometimes a Bachelor of Science degree might indicate that a student has taken more courses in the sciences (as would be the case in engineering-related fields) as opposed to the arts or humanities. Conversely, the Bachelor of Arts degree might indicate that the student has taken more courses in arts and humanities than in the sciences. Whatever the case, degree programs are rooted in the history of the higher education institution offering the programs and are confounded by the changing nature of the institution over time. There is very little agreement among educators, therefore, regarding the perceived differences between the Bachelor of Sciences and Bachelor of Arts degrees. It can be said, however, that typically the B.S. and B.A. degrees are awarded at four-year institutions, while the Associate of Science or Associate of Arts degrees are awarded at two-year community college or technical schools. While the differences in the designations of academic degrees in and of themselves are not that important, they do serve as a benchmark and relate to academic programs in terms of generally accepted admission standards, programs of study, and levels of accomplishment.

Unlike degrees, certification is typically related to a specific field or discipline and involves generally accepted standards from the community of professionals in a given field or area. Certification standards extend beyond one's institution and, in the case of conventional four-year technology teacher education programs, these standards are usually prescribed by state boards of education. In a 1989–1990 national survey of state certification procedures for technology education, Wicklein (1991) found that most certification requirements included either the National Teacher's Exam (NTE) core battery, NTE specialty in technology education, or a combination of the two. Wicklein further reported that approximately two thirds of the states surveyed were planning future certification changes for technology education.

Today most institutions that award degrees to prospective technology education teachers are accredited by the National Council for the Accreditation of Teacher Education (NCATE). Recently the International Technology Education Association (ITEA) and the Council on Technology Teacher Education (CTTE) have worked closely with the NCATE to develop official standards against which all technology teacher education programs seeking NCATE accreditation will be evaluated (Wiens, 1990). A major purpose of the ITEA/CTTE/NCATE standards is to ensure some consistency among undergraduate programs that prepare teachers in technology education.

CONVENTIONAL GRADUATE PROGRAMS

The history and development of graduate study in technology education is well documented (Buffer, 1979; Karnes & Lux, 1961; Norman & Bohn,

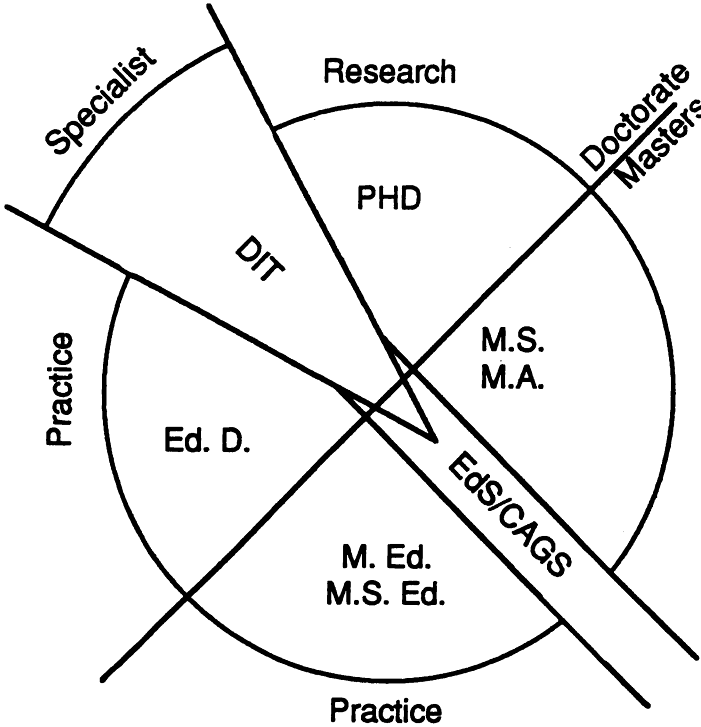


Figure 14-1: Degree emphasis of popular graduate degrees (Wright, 1986).

1961; Wright, 1986). Several degree emphases as outlined by Wright (1986) are shown in Figure 14–1. Typically, master's degrees have been designed to strengthen the preparation of practitioners, to develop skills of inquiry, or to develop leadership skills. The purposes of master's degree programs should not be to fill in deficiencies of undergraduate programs (Karnes & Lux, 1961). According to Swanson (1974), master's degree programs should not allow over 25% of technical work to be counted towards the degree completion requirements.

Doctoral programs, on the other hand, have traditionally served the dual purpose of training research scholars and preparing teacher educators and/or leaders for the field. While early distinctions were made between the Doctor of Philosophy (Ph.D., a research degree) and the Doctor of Education (Ed.D., a professional degree), Buffer (1979) stated that research and practice are a part of both degrees today with the distinction being more symbolic than real. In both instances, the emphasis is on the generation of new knowledge and the improvement of professional practice through research.

The Doctor of Industrial Technology (D.I.T.) is an alternative to Ph.D. and Ed.D. degree programs and currently exists only at the University of Northern Iowa. White (1984) noted that two distinctions of this degree are that it requires an internship and an advanced specialization in industrial technology. Unlike the Ed.D. or Ph.D. programs in technology education, the D.I.T. is a practitioner-oriented degree that focuses on the extension and application of industrial technological practices. The D.I.T. degree designation has not gained popularity in technology education since the Ed.D. and Ph.D. degrees remain the prevalent degrees offered throughout the world.

Master's and Specialist Degrees

Buffer (1979) identified the Educational Specialist (Ed.S.) and the Certificate of Advanced Graduate Studies (C.A.G.S.) as advanced degrees. They have the special purpose of fulfilling the needs of those wishing to extend their professional growth in the areas of administration or supervision in industrial or technology education. These degrees have been required for persons with occupations such as supervisors or entry-level personnel in community colleges or technical schools (Wright, 1986).

Wright (1986) drew a distinction between practice-oriented degrees and research-oriented degrees. He stated that "practice-oriented degrees such as the M.Ed., M.F.A., or M.B.A. are designed to advance knowledge for applications and typically have a technical component, and/or written/oral examinations. . . . The M.A. and M.S. degrees are usually considered research degrees" (pp. 202–203). The M.Ed. degree has recently gained additional prominence in five-year (B.A. plus master's) models for initial teacher preparation. In reality, however, one would find it difficult to distinguish differences in entrance and exit requirements for any of the degrees regardless of their designation.

The M.Ed., M.S., and the M.A. degrees, with the emphasis in technology education, are very popular post-baccalaureate degrees for the field. The typical master's program requires a point of entry (or admission), approximately one year of full-time equivalent study in a designated curriculum, and a final research or applied professional practice experience as a capstone to graduate studies. Admission into a master's program varies from institutional program to institutional program in technology education. Generally, a minimum grade point average is required along with an acceptable score on a standardized test such as the Graduate Record Examination (GRE) or Miller's Analogies Test (MAT). Most programs require a baccalaureate or equivalent degree in technology education for admission, however, post-baccalaureate degree certification programs currently being designed may require a baccalaureate in a related field. Other admission requirements may be imposed by the college, graduate school, or university in which the program is housed.

The program of studies or curriculum for which the master's degree is designed varies according to the designated outcome. Some degree programs, M.Ed. or M.S., may require a technical and technological core set of studies in technology education (Wright, 1986). The Master of Arts typically requires courses in the broader educational arena, courses in research, and possibly a comprehensive examination and/or master's thesis. Since the M.Ed.'s major purpose is to improve professional practice, its curriculum is usually more grounded in practice than those of the M.A. degree. The M.Ed. students complete an expanded core of integrated studies in education and a performance examination. A written examination or a practice-oriented research project is required as a final activity.

It is difficult to generalize the entrance and exit requirements for a master's degree whether they result in an M.Ed., M.S., or M.A. in technology education. Typically, most degrees have a culminating experience that may be a thesis or project and/or written and oral examinations over one's course of study. The requirement of a master's thesis has waned and appears to be more prevalent at those institutions that do not offer doctoral degrees. The written project or examination that demonstrate one's ability to enhance professional practice seem to be the typical exit requirement for the master's degree in technology education.

Doctoral Programs

The doctorate with an emphasis in technology education (and its forerunner, industrial education) has been around for quite some time. Karnes and Lux (1961) noted that the major purpose of the doctorate was to prepare a member of a teacher education staff whose major responsibilities were related to professional aspects of teacher education or to development of research skills. Buffer (1979) noted that the Ed.D. and the Ph.D. are the two most prominent degrees offered in the field in the United States.

Differences in doctoral programs in technology education arise from a conflict regarding differing views towards the principle mission of the field of technology education (Lux, 1974). For example, comprehensive vocational education doctoral programs include the fields of technology education, trade and industrial education, home economics education, and agricultural education. This organizational schema focuses on relationships in the practical arts (Evans, 1974). On the other hand, some programs have desired to develop doctoral studies focused solely on technology education. DeVore (1991) stated in *The Essential Elements of a Quality Graduate*

Technology Education Program (CTTE Monograph No. 12) that one's philosophical paradigm guides the nature of a graduate program in technology education.

Doctoral degree programs have three general components that comprise their structures. The first component is the course work and residency phase. Typically candidates are required to spend a minimum of one to two years in residence on campus for a focused period of study and social integration with peers and professors. The D.I.T. candidates are also required to spend a period of time in industry through internships. A common core set of experiences is required in a typical doctoral program and includes courses in what Wright (1986) has identified as "history and technology," "readings in technology," and "contemporary problems in technology." All doctoral programs require course work focusing upon quantitative and qualitative research methodology and the development of research skills. Additional course work in a cognate field might be determined by the extent to which a program is focused on some degree of specialization. For example, one might pursue formal study in technology, leadership, organizational development, or curriculum in technology education; or one might become more of a generalist taking courses with peers in other disciplines.

The second component of doctoral studies usually culminates with a comprehensive examination that may be written, oral, or a combination of the two. The examination is prepared and evaluated by a student's doctoral advisory committee. Successful completion of this component enables a student to begin the final phase of doctoral work.

The third component of doctoral studies involves the practical application of research. Often called the dissertation phase, the candidate is required to develop a dissertation prospectus, conduct research, and develop a written comprehensive research document. A final oral examination (dissertation defense) is required for the candidate to complete all of the requirements for the doctoral degree.

EMERGING MODELS IN TECHNOLOGY EDUCATION

In the previous section, an overview was presented for conventional or traditional programs at the undergraduate and graduate levels in technology education. While these models still currently dominate the status quo in technology education, there are several emerging models that must be considered. The models of the past were sufficient for preparing industrial arts teachers and teacher educators at that time. Political and economic trends, however, have dictated teacher education reform movements that are greatly affecting technology education. Householder (1992) challenged the field to move to new paradigms when planning for future technology teacher education programs.

Graduate Education

There are several new models that are having a dramatic effect on technology education graduate programs. At the master's level, teacher education programs are being affected by the development of post-baccalaureate degree certification programs. Undergraduate teacher preparation is being eliminated to allow more time for an in-depth study in general or liberal studies prior to the time that a student enters a professional teacher preparation program. Unlike the traditional model, the master's program is redesigned with a focus on professional education and in-depth clinical work in schools or similar settings. Practice-oriented research projects that have direct application to schools, as opposed to the more theoretical research requirements of M.A. and M.S. degree programs, are implemented. Post-baccalaureate degree certification programs (or fifth-year master's programs) allow little time for the development of the technical/technological component that was described earlier in this chapter.

Doctoral programs are also experiencing new paradigms. For example, the New Liberal Arts (NLA) and Science, Technology, and Society (STS) movements have opened doors for technology educators to be involved in interdisciplinary work at the undergraduate level and have provided new opportunities for interdisciplinary doctoral research. Doctoral programs are also being forced to be more responsive to the development of the master teacher or teacher leader concept for practitioners who intend on spending their entire careers in the classroom.

Financial constraints have caused many states to take a serious look at the redundancy in both graduate and undergraduate technology education programs. In the past, literally any institution that desired to have a program in industrial arts was given authorization to begin one (Lux, 1974). Economic-driven restructuring efforts of the 1990s, however, have forced technology teacher education programs to demonstrate their unique contributions to state-level teacher education. As a result, some institutions will retain undergraduate teacher education programs (their strengths) and others will, according to Moss (1989), "feel considerable pressure to reduce the size of—or even to eliminate—undergraduate teacher preparation pro-

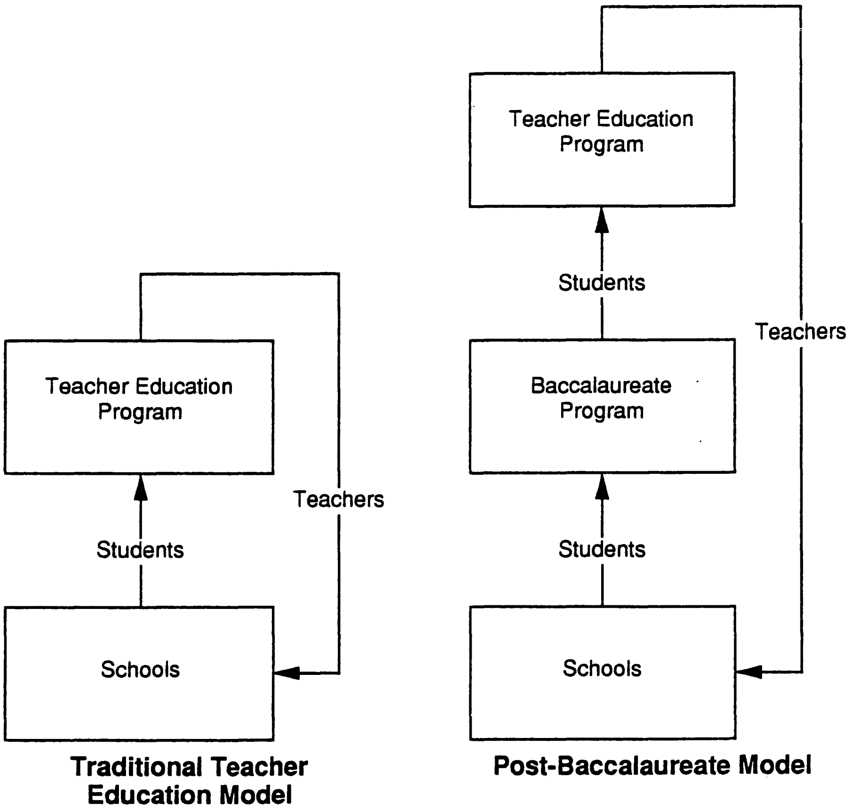


Figure 14-2: Traditional and post-baccalaureate program models (Householder, 1992).

grams and place greater emphasis upon graduate education and research and development activities" (p. 25).

Undergraduate Education

There are several new paradigms emerging for technology teacher education for the future. Householder (1992) provided an excellent summary of these models in his paper entitled "Redesign of Technology Teacher Education: Model Programs for the Future" in *Critical Issues In Technology Education, Camelback Symposium: A Compilation of Papers*. A summary of these models is presented in the following paragraphs.

Figure 14–2 depicts what Householder refers to as the traditional and

Holmes (post-baccalaureate) teacher education models. In the traditional model, Householder (1992) makes the following points:

1. Industrial arts teacher education programs evolved as distinct undergraduate majors housed in specialized departments in colleges and universities across the United States.
2. These intact, integrated departments recruit their students directly from high schools.
3. Departmental faculty members taught the courses in the major departmental laboratories and supervised student teaching experiences.
4. Most of the graduates went directly into teaching positions in the public schools and tended to remain in those positions. (p. 4)

In the post-baccalaureate degree certification model (or what Householder refers to as the Holmes Model), both the Carnegie Forum on Education and the Economy and the Holmes Group have proposed that all teachers receive a comprehensive liberal arts education at the undergraduate level to gain subject matter expertise, and that most teacher education courses be shifted to the graduate level. This model also calls for new interrelationships or internships between teacher education programs and schools (called Professional Development Schools) very similar to the teaching hospital model in the medical profession. The model also allows for the development of career ladders or differentiating staffing of teachers and the implementation of an induction year into the teaching position, using master technology education teachers as mentors for internship or new technology teachers. Figure 14–3 shows a comparison between conventional and post-baccalaureate certification models in terms of the three generally accepted components of teacher education as depicted by LaPorte (1993).

Young and Householder (1991) have developed the Interdisciplinary Technology Program at Texas A&M University, which they refer to as "an alternative paradigm for a large research university with strong programs in engineering and a variety of other technical fields" (p. 7). In their model, the baccalaureate major is essentially outside the professional field of education, utilizing courses in math, science, and computer science as well as technical courses that typically would be designed for students in engineering or technical majors. Unlike the traditional approach, technology education faculty do not teach technical courses in this model.

Hull and Parnell (1991) have extolled the virtues of Tech-Prep programs. Householder (1992) viewed Tech-Prep as offering new opportunities for technology teacher education. In addition to being a part of the high school

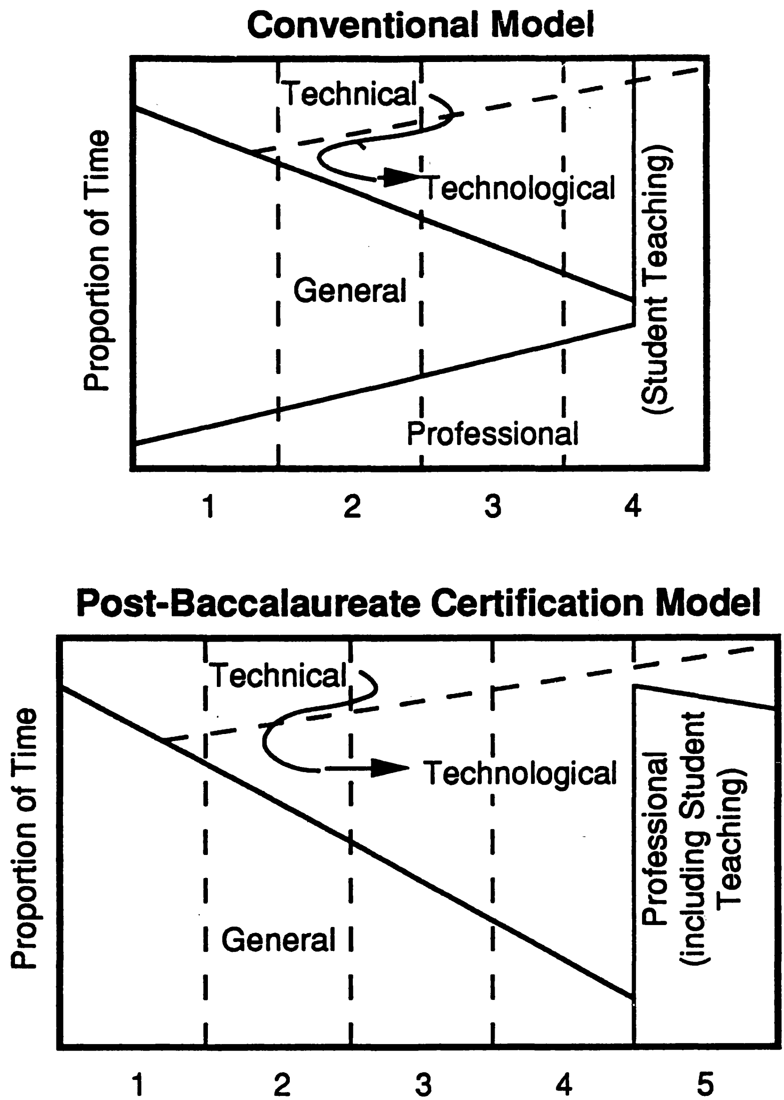


Figure 14-3: Comparison of time spent in three components of teacher education by year. Conventional versus post-bacculaureate certification models. (Adapted from LaPorte, 1993)

program of Tech-Prep, technology teacher education can be a part of two-plus-two programs in high schools and technical/community colleges and receive students into baccalaureate programs for the purpose of teacher preparation. Anderson (1992) stated, however, that considerable work needs to be done if technology education is to become a part of Tech-Prep. His review of literature concluded that technology education was not playing an active role in the Tech-Prep movement.

Loepp (1992) and LaPorte and Sanders (1993) have conducted exciting research and development projects involving interdisciplinary efforts among science, mathematics, and technology education. Householder's Science, Mathematics and Technology model as shown in Figure 14–4 demonstrates the possibilities for redesigning technology teacher education to enable it to become a major player in the mainstream of teacher education by taking advantage of opportunities available in science and mathematics. Similar interdisciplinary efforts should be undertaken with colleagues in social studies (and possibly science) to develop STS-like opportunities referred to earlier in this chapter by Wiens (1988).

Householder's inservice model as shown in Figure 14–4 "relies upon post-baccalaureate work to prepare and upgrade the competencies of teachers who are already in the workforce" (1992, p. 8). Householder noted that this model is used successfully in Britain for preparing primary and secondary teachers to implement technology programs in their national curriculum and, he believes, there are some possibilities for transferability to schools in the United States.

Householder's last model, The Integrated Paradigm Model as shown in Figure 14–5, is referred to as "integrated" because it provides several different ways to enable one to enter a teaching career. It also combines many possibilities that were exhibited in his previous models. Householder envisions the integrated model as an opportunity for recruiting teachers from math and science (and other disciplines), as well as those people retiring from technical fields in the industrial sector. The integrated model could provide a new and exciting pool of prospective teachers to enter fifth-year post-baccalaureate degree programs.

ISSUES AND QUESTIONS FACING TECHNOLOGY EDUCATION

In a guest article that appeared in the *Journal of Industrial Teacher Education*, Evans (1992) questioned why so little had been published about what he calls the sad state of teacher education in our field. Evans stated the following:

> It seems probable: (a) that a number of institutions which provide teacher education in our field has been declining for more than a

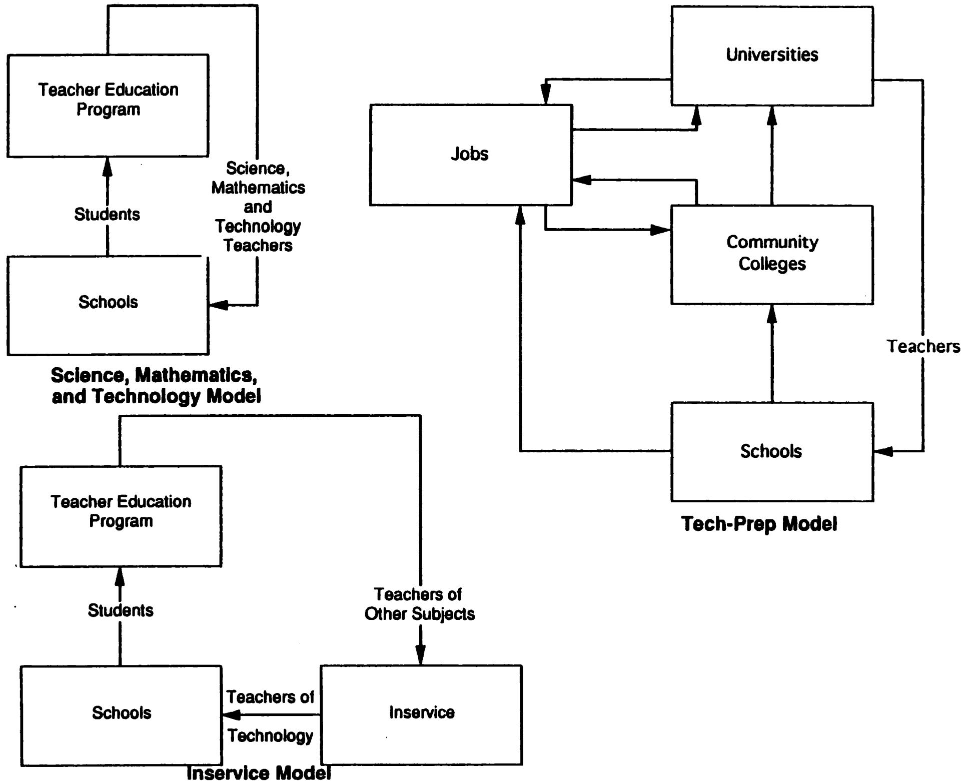
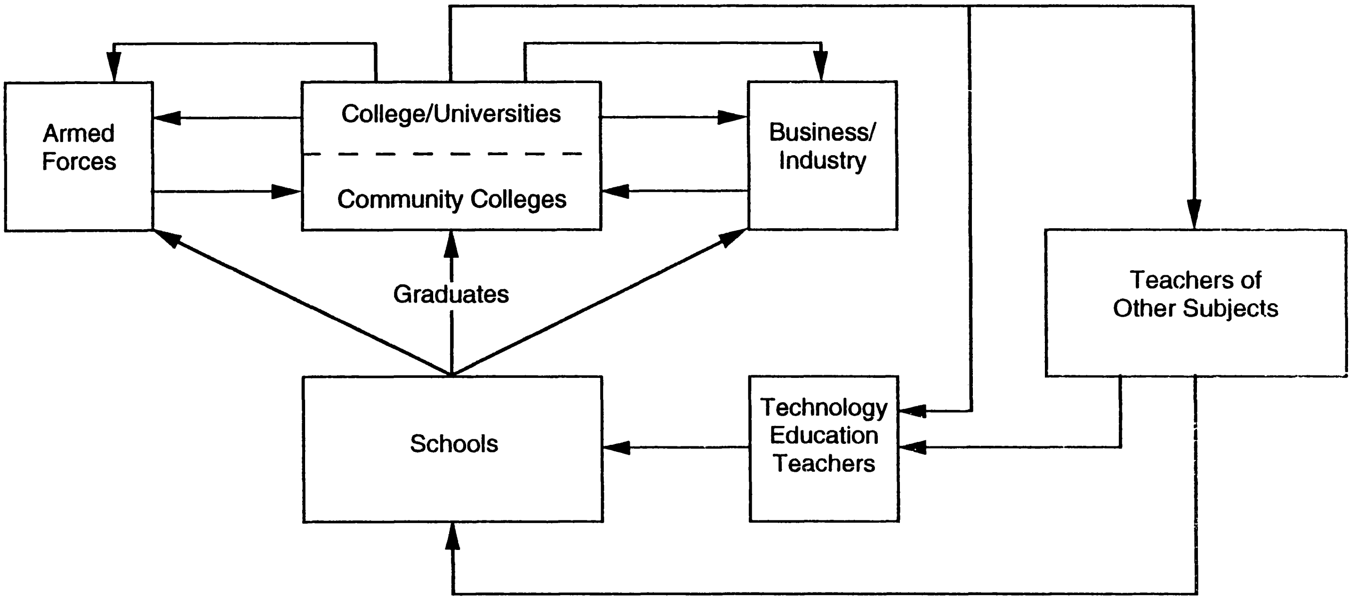


Figure 14-4: Alternative paradigms of technology teacher education (Householder, 1992).



Integrated Model

Figure 14-5: Integrated paradigm of technology teacher education (Householder, 1992).

> decade, and that the rate of decline has increased sharply in the past year; (b) that the number of teacher educators in our field has declined even more than the number of institutions; (c) that the number of persons completing our teacher education courses or programs have declined even more rapidly than the number of teacher educators; (d) that the numbers of our programs and teachers in secondary schools have also been decreasing, and that the demand for new teachers is very low—perhaps lower than it has been for more than 50 years; and (e) that the average age of our teachers is at an all time high. (p. 7)

Volk (1993) supported Evans' claims in his research, which showed that between 1970 and 1990 there were 71.9% fewer baccalaureate degrees awarded, 63.2% fewer master's degrees awarded, and 40% fewer doctorates awarded. Similar reductions in the number of graduates from technology teacher education programs were reported by Householder (1992), when he stated that "only a small number of technology teacher education programs currently graduate more than 10 teachers per year" (p. 6). The decline in undergraduate and graduate programs in technology education have come at the very same time that public school programs have experienced similar reductions because of factors such as increased graduation requirements, economic cutbacks, and closure of programs due to the lack of supply of teachers.

These problems have come at a time when the whole field of teacher education is under increased scrutiny by its public and is being forced to examine radical models of redesign. If, therefore, technology teacher educators are to "get their ship in order," there are several issues and questions that will need to be addressed. First, the field needs to re-examine its purpose or mission. Second, an examination of the clientele served by technology education needs to be undertaken. Third, technology educators need to be aware of the external threats facing them and have a plan of action for responding to such threats. Fourth, the issue of standards (accreditation and teaching) needs to be addressed. Finally, issues such as the application of technical credit (towards degree requirements) need to be reevaluated and a determination made as to whether or not the continuance of such practices is still in the field's best interest.

The Cloudy Mission

A cursory review of the *Industrial Teacher Education Directory* (Dennis, 1992) demonstrated that many different activities are occurring under the name of technology education. In most cases, technology (teacher education programs) are taught concurrently with industrial technology (industry-bound) programs. The issue is whether or not such mergers are in the best interests of technology education and if they fit its mission. Such dual programs may allow for the sharing of certain core courses between types of majors. Lauda (1988) stated that the combination of such programs may be a technique for keeping programs administratively viable for economic reasons. As Volk (1993) pointed out, however, "the decline of IA/TE graduates from those universities offering industrial technology programs has been significantly greater than those that do not offer such options" (p. 54).

At the graduate level, technology educators often find themselves combined with other vocational subjects in practical arts or comprehensive vocational education programs. Again, one has to question the general education mission of technology education if its graduate program is driven from a philosophical point of view, focusing on occupational pursuits.

Clientele

Problems or issues related to clientele are really related to the aforementioned issues centered around the mission of technology education. Who are we serving? Are we, for example, in the future business of providing massive numbers of technology education teachers for elementary and secondary schools? The data suggest not. Should the major role of doctoral programs be to prepare technology teacher educators at a time when demand for such is declining?

These and other questions center around the clientele that we serve in technology education. As previously mentioned, the traditional model of technology teacher education allowed for recruitment of students from high schools into undergraduate programs to prepare them as teachers of technology education. Many of these same persons then matriculated into graduate programs at the master's and doctoral levels in technology teacher education. As noted by Householder (1992), this model simply is not working anymore. Consistent with some of the new models emerging in technology teacher preparation are interesting opportunities for a recruitment program utilizing a different pool of students. New clientele entering technology teacher education, both at the graduate and undergraduate levels, might include persons from allied technical professions, other teaching professions, and/or retired military or other government service persons. Many of these persons, who already hold a baccalaureate degree, could be prospective technology education teachers if the profession modified some of its valued practices, such as a requirement for a strong focus in technical courses as a prerequisite to entrance requirements into our programs. This requirement alone has eliminated a large number of potential applicants from entering our field, and we really don't have a research database to support its value.

Pure economic survival and market demands have driven many dual-purpose technology education programs (teacher preparation and industry-based) to make major shifts to being solely industry-based (Lauda, 1988; Oaks & Loepp, 1989; Volk, 1993). Do we continue to allow teacher preparation programs to exist at the expense of non-teacher preparation programs, or do we try to strike a more equal balance between the two types? It may be, for instance, in the best interest to close the teacher preparation component completely, rather than continue to run very weak programs. Conversely, other institutions might focus on teacher preparation at the expense of industrial technology. This could allow respective institutions within a region to capitalize on their strengths and not try to be "all things to all people." In the past, technology educators have had the luxury of providing both types of curriculums, but political and economic demands of the future will force tough decisions that ultimately might ensure the survival of technology teacher education.

A related issue to preparing teachers is the preparation of teacher educators and/or leaders in doctoral programs. Assuming that doctoral programs will be pure technology teacher education oriented, where will these graduates go? Are there, for example, enough teacher education positions available for the graduates who are produced by institutions like The Ohio State University, University of Illinois, University of Minnesota, Virginia Polytechnic Institute and State University, Texas A&M University, and University of Missouri (to name a few)? Should these institutions be providing a more eclectic program that would allow graduates to expand their options for employment? Evans (1974) stated that "when a professor accepts a doctoral advisee, he [she] also accepts an implicit, moral responsibility for seeing that the advisee completes the program successfully and is placed in a satisfactory job" (p. 81). With an increased number of technology teacher education programs closing and a decreased demand for pure technology teacher educators, do we have an ethical responsibility not to overproduce technology teacher educators? Solutions to these problems are not easy. They will require, at a minimum, a cooperative effort among all doctoral degree institutions in technology education to study the problem collectively and to work collaboratively towards solutions. Such solutions might require inter-institutional agreements regarding the types and numbers of doctoral graduates each is producing. Furthermore, some institutions may prepare graduates for both industrial technology and technology teacher education, while others will simply focus on technology teacher education. Other institutions might develop more comprehensive programs, with areas like vocational education, science, or social studies.

External Factors

With the advent of the 1980s, there was a growing realization that the external environment is having a profound impact on technology teacher education programs (Dugger, 1985; Moss, 1989; Lewis, 1991). One external factor is the proliferation of so-called educational reform movements such as *A Nation at Risk* (National Commission on Excellence in Education, 1983); *A Nation Prepared* (Carnegie Task Force on Teaching as a Profession, 1986); and *Tomorrow's Teachers* (Holmes Group, 1986). Related to these reform movements have been other external factors, such as certification issues and increased scrutiny of practical education courses in both public schools and higher education environments.

Many technology educators believe that proposals by the Carnegie Forum on Education and the Economy and the Holmes Group, which require teachers to receive a comprehensive liberal arts education at the undergraduate level and to shift most teacher education courses to the graduate level, are new ideas. They are not! In fact, in a chapter entitled "Some Emerging Trends And Their Implications," Sherman (1962) proposed the concept of a five-year program for preparing teachers in industrial arts (technology education) for the reason that "a competent, educated teacher requires more preparation than could normally be provided in a baccalaureate degree program" (p. 78). In the same yearbook chapter, Sherman stated "we must give serious consideration to the necessity of planning for a five-year program" (p. 173). Miller (1991), in his examination of models for preparing teachers of technology education, stated that "a five-year program that grants a master's level may be the logical approach to preparing technology education teachers" (p. 69). Even though this idea was proposed over 30 years ago, it now appears that the time is right for technology teacher education to give serious consideration to post-baccalaureate degree certification. Such programs have already been proposed and are in place at institutions like the University of Minnesota and The Ohio State University. The issue for technology education is to identify what courses should be required at the undergraduate level to ensure a liberal arts preparation that complements technology education. Unlike other disciplines (such as foreign language education, math education, science education) there is no complementary undergraduate liberal arts (arts and sciences) major that naturally feeds into fifth-year technology teacher education programs. Texas A&M University's B.S. degree in Interdisciplinary Technology (Young & Householder, 1991) is one example of a new paradigm, but certainly not the only model, that technology teacher preparation programs should carefully examine. Research is needed to provide further insight into this issue.

Another radical proposal from Carnegie, Holmes, and the leadership in teachers' associations is professional development schools and an induction year program for new teachers. Unlike its predecessor (student teaching), professional development schools and induction year programs require a closer relationship between technology teacher education programs and respective school systems in the preparation of teachers. Furthermore, technology teacher educators would develop new structures allowing for longer (perhaps one year or more) internships for new teachers. In this model, master technology education teachers would assume the major responsibility in the supervision of new teachers and would be involved in instruction in some of the professional courses at colleges and universities. This might require the development of new roles (e.g., clinical faculty) for these professionals and a willingness on the part of current teacher educators to accept this model as a true collaborative effort to improve the way technology education teachers are prepared.

In an effort to devise procedures to identify the skills and knowledge essential to good teaching practice, several educational reformers are developing innovative teacher assessments. Two of these organizations are the National Board for Professional Teaching Standards (NBPTS) and the Educational Testing Services (ETS), whose new performance-based assessment (PRAXIS) is designed to replace the National Teacher's Examination (NTE). Wicklein (1991), in his research of certification practices for technology education teachers, found that the majority of the states that he surveyed were in the process of making certification changes. More than likely, most of these states will adopt the ETS's PRAXIS process as a method for measuring excellence in technology teacher education. It is envisioned that these assessments will be used as measures for determining the licensure of teachers who will be entering the teaching profession. New methods of measurement such as portfolio assessment or authentic assessment will need to be developed as a part of technology teacher education programs.

Unlike the ETS's PRAXIS, the National Board for Professional Teaching Standards (NBPTS) is in the process of developing a voluntary national system for teacher certification. The NBPTS believes that board-certified teachers will gain additional credibility like board-certified professionals in other fields such as law, medicine, and accounting. Shapiro (1993) stated that the NBPTS was formed in 1987 from a recommendation of Carnegie Forum task force on teaching and that there are 36 areas in which the national board certification will be offered. Technology education is not listed as one of the separate areas, and it remains unclear at the time of this writing as to whether or not board certification will be available under what the NBPTS refers to as vocational education.

Other certification issues that may have a profound effect on technology teacher education programs are what Lewis (1991) refers to as alternative credentialing and recertification. Alternative credentialing empowers local school districts to prepare part of the teaching personnel for their districts. Although required to work with institutions of higher education, the school districts may or may not utilize recommendations from such institutions. Recertification, like alternative credentialing, requires "a second-stage state teaching certificate" (Lewis, p. 28) but again very few institutions of higher education are found to be involved in the recertification process. These external movements in alternative credentialing should be particularly troubling to technology teacher education professionals. If, in fact, certification is increasingly moved to local school district control, away from institutions of higher education, the mere existence of technology teacher preparation programs can be questioned.

There is general agreement that undergraduate and graduate programs in technology education need to be improved and that some external involvement in such programs can contribute to their revision and/or restructuring. The central issue is, however, who should be empowered to exercise this external control: the Council on Technology Teacher Education (CTTE), state education agencies, accrediting associations such as NCATE, or other external organizations? Starkweather (1991) claimed that the ITEA/CTTE/NCATE accreditation process has resulted in improving technology teacher education programs that have gone through the process. Wiens (1990) stated that "data clearly show that the ITEA/CTTE/NCATE guidelines are not fully supported by state certification requirements" (p. 63). Wiens' study documented the conflict that exists between state education agencies and ITEA/CTTE/NCATE in determining who should exercise external control over the quality of technology teacher education programs. Furthermore, Householder (1992) stated that "current ITEA/CTTE/NCATE guidelines for the approval of technology teacher education programs assume a program model which reflects the traditional industrial arts teacher education model in many organizational attributes" (p. 6). Householder's point is that the guidelines that the profession has developed in conjunction with NCATE to upgrade the field perpetuates the traditional model of technology education and does not recognize the new emerging paradigms for technology teacher preparation. Clearly, more work needs to be done with this accreditation process. The technology teacher education checklist (Householder & Boser, 1991) has been offered as an alternative for assessing the transition from traditional industrial arts programs to futuristic technology teacher education programs.

Another issue facing technology teacher education is the application of technical credit towards academic degree requirements. Clearly, at a time when teacher education reform is calling for more studies in general or liberal education, such increases come at the expense of technical courses, not professional courses. Furthermore, in post-baccalaureate certification programs, professional courses are moved to the master's level and the technical courses left at the undergraduate level are threatened by increased requirements for general studies. As previously mentioned, Swanson (1974) questioned any master's program that offered more than one fourth of its credit for technical courses. Others would claim that technical credit has no place at all in a master's degree program.

The appropriateness and value of technological studies at the baccalaureate and master's levels and certificate of advanced graduate studies should be apparent, especially given the purpose and nature of these degree programs. Each is designed to provide for initial certification as technology educators or to enhance their professional practice and performance in schools. The challenge is for technology educators to break away from the liberal arts and science models of graduate study and adopt a professional practice model so that teachers may focus their studies on the improvement of those skills and kinds of knowledge directly related to their professional practice. Thus, technology educators would benefit from taking a significant portion of their course work in technological studies as well as cognate fields of organizational development, leadership and management, and social and human services.

The issue of technical credit, particularly at the graduate level, will not be resolved easily. One approach would be to describe technical studies as an essential part of one's liberal studies and professional competencies of practicing. History has shown, however, that this argument is likely to fail with colleagues in the liberal arts. Another option is to offer a different degree structure for those seeking higher concentrations of technical credit in their programs. Master of Science (M.S.) degrees or Bachelor of Science degrees might be offered as an alternative to the Master of Arts or Bachelor of Arts degrees. Other options might be to allow for the transfer of technical credit into four-year institutions from community colleges or technical schools and, to a lesser degree, to offer fewer such courses in four-year institutions. At any rate, technology educators are finding it more difficult to get technical courses accepted for credit, especially at the graduate level. According to Buffer (1979), " A [technical] course should be considered graduate level if class requirements stimulate thought and require students to . . . synthesize, evaluate, and solve problems enabling one to gain new knowledge [as] the ultimate goal of scholarly study" (p. 315).

FUTURE DIRECTIONS AND EXPECTATIONS

The issues and questions that were previously described are only a few of the challenges that the profession can anticipate in technology education in the 21st century. Some of the emerging paradigms are admittedly bold. Some are certain to fail, while other models will be remarkably successful and may, in fact, be the needed prescription to inject vitality into what are currently seen as weak undergraduate and graduate programs. As technology teacher education programs respond to the declining number of programs in public schools, the role of technology teacher educators will undoubtedly change. Some of the changes will be in response to badly needed new paradigms for technology teacher education. Other changes will be in response to external forces affecting the needs of a changing educational system in general. In light of these changes, the following directions for undergraduate and graduate programs in technology education are forecasted:

1. Current degree structures will change substantially. As technology teacher education programs are moved to the master's level, we will see more development of M.Ed. programs recognizing educational and technological practice and applied research, in addition to theoretical research inherent in the Master of Arts degree. Furthermore, the development of Master of Science degrees seems to be an appropriate way of distinguishing those programs with great emphasis on technical/technological components from those more heavily weighted in liberal arts studies.

2. The field will continue to struggle with dual programs that offer both education and non-education programs. Either a good balance will be struck between education and non-education programs or we may see the demise of one or the other (or both). Within states, some institutions will focus purely on teacher education, giving up their non-education options, while others will focus on industrial technology, giving up their educational programs.

3. Technology teacher educators will work more closely with school districts. The introduction of professional development schools, induction programs, and teacher leaders (clinical professors) will force a closer relationship between technology teacher education and technology education in the public schools. Degree programs that focus on professional practice will need to be developed to be more responsive to practitioners in public schools. In addition, the M.Ed.

and Ed.D. may exist alongside of M.A. and Ph.D. programs to respond to these new needs.

4. Consumer demand will drive the number of technology teacher preparation programs in existence at any point in time. As technology education in the public schools continues to decline, so will teacher preparation programs at colleges and universities. Over time this decline should level off and could moderately increase as new paradigms are developed for technology education in the schools. The key will rest on the acceptance of these new paradigms and the collaborative development of them by both public schools and technology teacher educators. The numbers of technology teacher education programs may never be what they once were, but hopefully the remaining number will be of high quality and will be able to supply the number of teachers needed for the future. An immediate concern will be a rapidly aging "baby boom" generation, many of whom will be retiring within the next decade. It is quite possible that new recruitment and certification practices will need to be implemented to serve this short-term need.

SUMMARY

The purpose of this chapter was to review undergraduate and graduate programs in technology education. A brief background and history was provided relative to the growth and the development of undergraduate and graduate degree programs in technology education. Unique characteristics, functions, and purposes of technology education degree programs were described.

An attempt was made to inform the reader of emerging new paradigms for undergraduate and graduate teacher preparation programs in technology education. Many of the emerging models were described in context with many of the changes that are currently in teacher education reform. Examples of new structures focusing on post-baccalaureate degree certification and interdisciplinary studies were provided.

Many of the issues and questions facing technology education programs were identified. Issues surrounding the purposes and mission of technology education were described, along with problems in identifying the clientele which the field is serving. The external threats facing technology education were described, along with external influences such as accreditation and certification. The suitability of technical studies as an integral part of graduate degree programs has long been a concern for technology teacher education and suggestions for resolving this issue was addressed in this chapter.

The authors made an attempt to outline what they perceive to be future directions or expectations for technology teacher education. These directions were chosen in light of such factors as degree structures, suitability of degrees, and the coexistence of education versus non-education programs. Finally, the perceived need for programs in light of future consumer or market demands was addressed. Now, as we prepare to enter the 21st century, it is time for some drastic paradigm shifts, time to be bold and to be risk takers, and time to take advantage of the opportunities to recapture the excitement of technology that permeates the minds and lifestyles of every young child and adult.

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CHAPTER **15**

Technology Education: A Global Influence

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Technology is one of the newest school subjects, and the study of technology and the resulting curriculum content being taught in schools is currently a worldwide effort that continues to gain momentum. As with any innovation in education, the process of adding a new subject to the school curriculum is meeting with acceptance as well as opposition from the public and the teaching profession alike. Perhaps Machiavelli (1513) capture the essence of the situation the best in the following quotation:

> There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things, because the innovator has for enemies all those who have done well under the old conditions.

Some of the most convincing seminal research in technology education to date has not been done in the United States, but in countries like Great Britain, The Netherlands, and Australia. The purpose of this chapter, therefore, is to examine the significant activities and events in countries other than the United States, while focusing on the past, present, and future of technology education from a global perspective.

OVERVIEW

Basic Definitions of Technology Used Around The World

In the past decade, the technology education profession has experienced a quantum shift in the philosophical organizer of the discipline from crafts and industry to technology. One result of this shift has been that the profession has become less enamored with tools, machines, processes, and products and is becoming more interested in broader topics of significance, such as technological systems, problem-solving activities, impacts of technology, and even the interfacing with other disciplines such as science and mathematics. This new and growing interest has caused the technology education profession to address many topics including, but not limited to, the following: (a) What is technology?, (b) what definitions are evolving for this new school subject?, and (c) what is the difference between technology and technology education?

In one of the earliest statements in educational circles about technology in the United States, William E. Warner of The Ohio State University defined technology as the "science of industrial arts." Later, Delmar W. Olson of Kent State University and Paul W. DeVore of the State University of New York-College at Oswego completed pioneering work on technology education during the 1950s and 1960s. In 1981, a document entitled the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales) defined technology as follows: "The knowledge and study of human endeavors in creating and using tools, techniques, resources, and systems to manage the man-made and natural environment for the purpose of extending human potential and the relationship of these to individuals, society, and the civilization process" (p. 2). (Chapter 7 of this yearbook provides a more complete discussion of *Jackson's Mill Industrial Arts Curriculum Theory* document.) In a 1990 International Technology Education Association (ITEA) publication entitled *A Conceptual Framework for Technology Education* (Savage & Sterry), technology is defined as follows: "A body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants" (p. 2). The ITEA's most recent definition, which is found in an article entitled "Technology Education–A Position Statement," Wright and Lauda (1993) defined technology as follows: "A body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment" (p. 3).

In Great Britain, the technology curriculum is considered a foundation subject that is required for all students ages 6–16. In the Department of Education and Science and the Welsh Office (1990) publication, *Technology in the National Curriculum*, technology is proposed as a new subject that requires pupils to "apply knowledge and skills to solve practical problems" (p. i).

Technology is often used as the generic term to encompass all the technologies people develop and use in their lives. The United Nations

Education, Scientific and Cultural Organization (1985) defines technology as the following:

> Technology is the know-how and creative processes that may assist people to utilize tools, resources and systems to solve problems and to enhance control over the natural and man-made environment in an endeavor to improve the human condition. (p. 1)

A 1992 document from the Australian Department of Employment and Training entitled *Technology for Australian Schools* defines technology as the following:

> The purposeful application of knowledge, experience and resources to create processes and products that meet human needs. The needs and wants of people in particular communities determine the technology that is developed and how it is applied. People judge the desirability of technological applications by their impact on health, personal well-being and lifestyle, economies and ecosystems. (p. 1)

It is evident from the sources that have been reviewed for the development of this chapter, that there is general agreement that technology involves the application of knowledge, resources, and human experiences either to solve problems or to control our world. The ultimate purpose of technology is to satisfy human wants and needs, while the resulting impacts of technology cause humans to realize that technology can create new problems. In a more simplified version, technology is coming to be recognized throughout the world as the study of the "human created and controlled world and universe" (Dugger, 1993). In contrast to this recognition for technology, science is recognized as the study of our natural world and universe (the natural sciences) (National Research Council, 1992).

Technology education is the school subject that teaches *about* technology. In many countries, technology education is considered to be a part of the core curriculum or to have curriculum content that is basic and needed by everyone, regardless of one's gender or ethnic background. Technology education, however, is sometimes confused with educational technology that uses technology as an enhancement in the teaching process. Educational technology emphasizes teaching *with* technology through media, audiovisual equipment, computers, and other similar forms of hardware and software. It is a means to an end, while technology education is considered a content discipline equal in status to mathematics, science, language arts, and social studies.

In the article entitled, "How to Avoid Becoming a Nation of Technopeasants," Hersh (1983) stated that the past decade of the 1980s had unprecedented developments in technology. He also stated that "we must acquire technological literacy" (p. 625) as a part of our educational experience. One definition for technological literacy comes from Franzie L. Loepp at Illinois State University, who stated that technological literacy is the "competency to locate, sort, analyze and synthesize information that relates to achieving practical purposes through efficient action" (1986, p. 37).

A technologically literate person understands the historical role of technology in human development, the relationship between technological decisions and human values, the benefits and risks of choosing technologies, the changes occurring in current technology, and technology assessment as a method of influencing the choice of future technologies (National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology, 1984). Literacy involves that part of education that everyone needs to know as a fundamental, core part of formal schooling. Literacy is generally defined as having a degree of competence in reading, writing, speaking, mathematics, and other skills.

In an article defining scientific and technological literacy, Bloch (1986) stated the following:

> Anyone who finishes high school should be able to read a newspaper or magazine article on technology-related issues of the day, such as medical research, environment, automation, or nuclear power.
>
> More important: High school graduates should be able to react to science policy issues that touch their lives not just on the basis of emotion, but on the basis of some understandings. They should be able to ask:
>
> - What are the facts?
> - What are the risks?
> - Do we know enough?
> - Who can be trusted to make the right decision and what is the decision process?
> - What are the consequences of different views?
>
> And any graduate should be able to make informed choices about educational and career directions.
>
> In short, scientific and technological literacy should provide an informed basis for public decision making. And pursuit of this objective is no longer a luxury. Scientific and technological literacy is a national necessity. (p. 139)

As technology education continues to evolve, there is a vital need for an accepted definition for both technology and technological literacy. The global movement in technology education underscores the profession's need to have a commitment to a common mission, purpose, and vision.

Development of Technology Education Worldwide

Technology education had its epistemological roots in the United States as a result of the work conducted by William E. Warner, Delmar W. Olson, Paul W. DeVore, and several others from the 1930s to the 1960s. Technology education became a serious school subject in Great Britain in the 1970s and 1980s through the work of Geoffrey Harrison, Paul Black, and others. Technology education in England and Wales has evolved from a program called Craft, Design, and Technology (CDT). England has been a leader in the development of school programs in technology through programs such as Project Technology, Microelectronics For All (MFA), British School Technology (BST), and the administration of university entrance examinations in technology. Key components of the British CDT programs in the 1980s included problem solving, design, and control technology.

Over the past five years, England's National Curriculum has been developed and implemented with three core subjects: English, mathematics, and science. The National Curriculum also consists of seven foundation subjects including technology/design, geography, history, arts, religious education, music, and modern foreign language. The curriculum operates in four key stages: KS1, ages 5–7; KS2, ages 7–11; KS3, ages 11–14; and KS4, ages 14–16 as shown in Table 15–1. National assessment tests are administered to all pupils at the end of each key stage. These tests have attainment targets that have differentiated but highly specific behavioral objectives. The attainment targets are based on the knowledge, skills, and understandings that students are expected to have at the end of each key stage, and there are 10 levels arranged in increasing level of difficulty over the four key stages. The technology/design foundation subject has five targets called attainment targets (AT) that include the following: AT1, Identifying Needs and Opportunities; AT2, Generating a Design Proposal; AT3, Planning and Making; AT4, Evaluating; and AT5, Information Technology. In addition there are four programs of study that provide a framework within which each school must construct its plans for teaching design and technology. These programs of study are the following: Satisfying Needs and Addressing Opportunities; Developing and Communicating Ideas; Developing and Using Artifacts, Systems, and Environments; and Working with Materials.

The author conducted several interviews to ascertain the status of technology education in various countries throughout the world. Claire

	COMPULSORY SCHOOLING												ELECTIVE	
	PRIMARY SCHOOL							SECONDARY						
Approximate age	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Year in School	R	1	2	3	4	5	6	7	8	9	10	11	12	13
CORE	**KEY**			**KEY**				**KEY**			**KEY**		**EXAM**	
SUBJECTS	**STAGE I**			**STAGE II**				**STAGE III**			**STAGE IV**		**COURSES**	
English		X	X	X	X	X	X	X	X	X	X	X	Examination subjects are chosen by individual students on the basis of interest, aptitude, and ability.	
Mathematics		X	X	X	X	X	X	X	X	X	X	X		
Science		X	X	X	X	X	X	X	X	X	X	X		
Natural		X	X	X	X	X	X	X	X	X	X	X		
Biology		X	X	X	X	X	X	X	X	X	X	X		
Physics /Astronomy		X	X	X	X	X	X	X	X	X	X	X		
Chemistry		X	X	X	X	X	X	X	X	X	X	X		
FOUNDATION SUBJECTS		X	X	X	X	X	X	X	X	X	X	X		
Technology/design		X	X	X	X	X	X	X	X	X	X	X		
History		X	X	X	X	X	X	X	X	X	X	X		
Geography		X	X	X	X	X	X	X	X	X	X	X		
Art		X	X	X	X	X	X	X	X	X	X	X		
Physical education		X	X	X	X	X	X	X	X	X	X	X		
Foreign language								X	X	X	X	X		
Careers education		X	X	X	X	X	X	X	X	X	X	X		
Guidance		X	X	X	X	X	X	X	X	X	X	X		
Health		X	X	X	X	X	X	X	X	X	X	X		
Personal/ Social ed.		X	X	X	X	X	X	X	X	X	X	X		
Gender issues		X	X	X	X	X	X	X	X	X	X	X		
Multicultural ed.		X	X	X	X	X	X	X	X	X	X	X		

Figure 15-1: Simplified representation of the subjects required of typical British students. (Source: Unks, G. [1992, December]. Three nations' curricula: What can we learn from them? NASSP Bulletin. Reprinted by permission of the author.) (Sources: Department of Education and Science, 1989; Lynch, D., 1992B.)

Benson, a technology teacher educator from the University of Birmingham in Birmingham, England, stated in a 1993 interview that technology education has been a compulsory subject for two years for pupils in the 5–7 and 11–14 age groups. It is now being introduced for the 7–11 and 14–16 age groups. The first governmental report in 1991 on the status of technology education in England gave an overview of its initial implementation in the primary and secondary schools. In the primary schools, 70% of the work that was reviewed was determined to be satisfactory or above. All the pupils who were interviewed expressed enjoyment with technology education and were enthusiastic to continue with it. There were concerns noted in the report, however, that included teachers' lack of confidence in teaching design and technology and their lack of knowledge and skills in using technology. Beginning in April 1992, there were design and technology courses for primary teachers throughout England and Wales. These courses required 100 hours for completion. Proposals for new elements of the curriculum became law in September 1993 and were implemented in the schools in September 1994. The principal changes were that the National Curriculum should exhibit the following characteristics: (a) It should be simpler, but this has led to some oversimplification of content; (b) there should be two attainment targets rather than four in designing and making; (c) the content should be much more biased towards science, especially physics; and (d) design and technology should be taught through design and make tasks (DMT).

An interesting comparison to the efforts conducted in England and Wales may be found in the work being conducted in Germany. A simplified representation of the subjects required of typical students in the Federal Republic of Germany is shown in Table 15–2. Gerd Hopken of the Pedagogische Hochschule in Flensburg, Germany reported the following:

> In the German Federal Republic, the federal states are independent in educational matters. Since the mid-'70s, technology education is replacing crafts in most of the German federal states in secondary schools (age 12–16). In elementary schools (6–10 or 12), in most states technology education is part of a comprehensive subject "Sachunerricht" including science and humanities. In upper secondary schools, technology education is taught only in one federal state (Northrhine-Westfalia). In most of the federal states in the last years 'new technologies' have been added to the content of technology education. (Interview with Hopken, April 1993)

In the Scandinavian countries of Finland and Sweden, there continues a century old tradition called *sloyd*. In Finland, Tapani Kananoja, retired supervisor for technology education in Finland, and Aki Rasinen, professor at the University of Jyvaskyla, reported in interviews that in the primary schools, grades 2–6 (age 7–13), there are two to three periods a week of *technical work* – a subject where technological contents are addressed. In the secondary grades 7–9 (age 13–15), there are three periods a week of *technical work* at grade 7. At grades 8 and 9, a student has an option to choose zero, two, or four periods a week of technical work. Boys mainly study technical work after grade 4, when a student must choose between textile work and technical work.

In Sweden, Thomas Ginner, Professor at the University of Linkoping, reported in an interview that the last review of the National Curriculum was in 1980, when technology became a compulsory subject. A new revision of the National Curriculum is now in progress. New and trendy basic values and targets are being put forward, and they are supposed to be transformed into the targets of each subject curriculum, including what is being proposed in the new curriculum for technology in Sweden. More freedom and responsibility will be given to the teacher with the revised curriculum. No didactic methods or fixed technological areas are given in the revised

	COMPULSORY SCHOOLING											ELECTIVE		
	PRIMARY SCHOOL					SECONDARY								
Approximate age	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Year in School		1	2	3	4	5	6	7	8	9	10****	11	12	13
Grade	K	1	2	3	4	5	6	7	8	9	10****	11	12	13
SUBJECT														
German language		x	x	x	x	x	x	x	x	x	x			
Sachunerricht (everyday life observations)		x	x	x	x							Gymnasium level courses. See text for description and discussion. Abitur (leaving examination) is usually taken at the end of year 13.		
Mathematics		x	x	x	x	x	x	x	x	x	x			
Physical education		x	x	x	x	x	x	x	x	x	x			
Music		x	x	x	x	x	x	x	x	x	x			
Art/textile work		x	x	x	x	x	x	x	x	x	x			
Religious instruct.		x	x	x	x	x	x	x	x	x	x			
Forderunterricht (remedial work for students to support and tutor them to keep up)		x	x	x	x									
Social science						x	x	x	x	x	x			
Natural science						x***	x***	x***	x***	x***	x***			
Foreign language						x	x	x	x	x	x			
Required elective								x**	x**	x	x			
Orientation class						x	x							
Technicals, economics, home economics								x*	x*	x*	x*			

Figure 15-2: Simplified representation of the subjects required of typical students in the Federal Republic of Germany. (Source: Unks, G. Three nations' curricula: What can we learn from them? NASSP Bulletin. Reprinted by permission of the author.)
*Notes: *Hauptschule only*
***Hauptschule and Realschule*
****includes biology, geography, physics, and chemistry, depending upon the availability of teachers trained in the respective sub*
*****some Hauptschule end at grade 9*
(Sources: Blasius, 1992; Fishman and Martin, 1986, p. 109, 147, 149; Fuhr, p. 233; Schweins, 1992.)

curriculum. Instead, a basic structure with important perspectives on technology will be developed in the future. The problem is that the National Curriculum Committee has proposed that technology should be linked with environment into a new subject called technology and environment.

Technology education is also undergoing changes in other parts of Europe as well. Technology education in Scotland, for example, is delivered through the curricular area of environmental studies for ages of 5–14. In the upper secondary curriculum, technology education is presented through the curriculum area of technological applications and activities.

Hana Nováková of the Czech Republic reported that the developed system of technology education there, as a part of the total general education curriculum, has been downsized in recent years. Technology education is a compulsory subject only at the primary school (grades 1–4, one hour per week; grades 5–6, two hours per week; grades 7–8, two hours optional per week). In the gymnasium, which is the upper secondary school, technology education has been eliminated totally from the curriculum. An effort being initiated in the Republic is a new curriculum for technology education for the 21st century, which may become effective as early as 1997. Nováková stated that a new draft of the technology education curriculum is currently being developed for the primary school. When implemented, the curriculum will focus on problem solving, developing creativity, and career choices.

In Africa, Raphael Kapiyo reported in an interview that technology education occurs in different versions within the Kenyan School System. At the primary school level, for example, the teaching of technology education is integrated with arts and crafts, agriculture and science, and home economics subjects. There is little evidence of the extent to which these courses cover technology, since there is no clear or accepted definition of technology in Kenya. At the secondary education level, technology education is still skill based, while containing little room for innovation and problem solving. Two years ago, however, one university started a department of technology teacher education. Kenya, like many other countries, will not avoid a more serious concern for technology in the school curriculum. At the present time, for example, there is already a growing concern for education for technological capability and technological literacy. The number of people becoming technology educators is rising and, in the near future, they will form a sufficient force to be able to influence education policy in Kenya. Technology education in the curriculum of Kenya should bring a strong positive change in peoples' attitudes toward technology.

Kapiyo also reported on the development of technology education in other countries of Africa. He stated the following:

Tanzania—This country has a strong community-based science and technology education program. There is no technology as a subject, but agriculture and community study courses are problem focused. These courses are mostly found in primary and secondary levels.

Uganda—The focus of studies is similar to the Kenyan one of arts and crafts, and science and agriculture, but it lacks the technological flavor which Kenya already has. The secondary courses are more industrial education.

Botswana—Much work has been accomplished here and they have implementation of a design and technology course.

Zimbabwe—They offer more vocational and technical education (metalwork, woodwork, automotive and electrical installations). There have been attempts with technology education and appropriate technology education at university and teacher training institutions. (Interview with Raphael Kapiyo, April, 1993)

P. van Schallkwyk, Potchefstroomse Universiteit vir Christelike Hoer Onderwys, Republic of South Africa, reported that, historically, technology has not been included in the school curriculum. A new proposal, however, that focuses on technology in the secondary school curriculum, has been developed but not implemented. Schallkwyk reported that perhaps it will be implemented after there is political change in South Africa. If technology can be included in pre-tertiary education in South Africa, Schallkwyk believes that there will be more concern about (a) the depletion of natural resources, (b) pollution, and (c) balanced technology among the students. A future goal is for South Africa to create sufficient wealth to support its own population and to contribute to the well-being of Africa and the rest of the world.

John Williams of the University of Newcastle, Australia, reported that technology education in Australia has been introduced into primary schools as a compulsory subject in grades 7 and 8. The subject is called science and technology and includes 100 hours of instruction per year in design and technology. In years 9–12, design and technology is offered as an elective subject while in grades 11–12, design and technology is replacing industrial technology. The focus of technology education has been to change from a teacher-centered, product orientation to a student-centered, process orientation, with an increased emphasis on the thinking skills.

Japan is known worldwide for its educational system, however, it has not adopted technology education as a basic part of its educational requirements. Industrial arts is still offered in Japan and all male students (ages 12–14) are required to complete it. Industrial arts is also offered as an elective in the upper secondary technical high schools (ages 11–13). Table 15–3 provides a simplified representation of the subjects required of a typical Japanese student.

In Taiwan, industrial arts, not technology education, is the predominant course being taught in the public schools. A strong vocational education influence may be a factor in causing technology education not to flourish as a core subject in that country. In the future, views on the acceptance of technology education will hopefully be more optimistic. Eventually, tech-

	COMPULSORY SCHOOLING										ELECTIVE		
Approximate age	5	6	7	8	9	10	11	12	13	14	15	16	17
Year in School	1	2	3	4	5	6	7	8	9	10	11	12	13
Grade	K	1	2	3	4	5	6	7	8	9	10	11	12
	ELEMENTARY SCHOOL							LOWER SECOND.			UPPER SECOND.		
Japanese language		X1	X1	X1	X1	X	X	X	X	X	X	X	X
Japanese literature						X	X	X	X	X	X	X	X
Mathematics		X2	X2	X5	X5	X5	X5	X6	X	X	X7	X	X
Science				3									
Natural				X4	X	X	X	X	X	X			
Biology						X	X	X	X	X	X	X	X
Physics						X	X	X	X	X	X	X	X
Astronomy						X	X	X	X	X	X	X	X
Chemistry						X	X	X	X	X	X	X	X
History						X	X	X	X	X	X	X	X
Japanese govt.						X	X	X	X	X	X	X	X
Social science								X	X	X			
Geography				X3	X	X	X	X	X	X	X8	X8	X8
Music & singing		X4	X	X	X	X	X	X	X	X	X	X	X
Fine arts		X4	X	X	X	X	X	X	X	X	X	X	X
Physical education		X4	X	X	X	X	X	X	X	X	X	X	X
Foreign language								X	X	X	X	X	X
Mech. drawing											X9	X9	X9
Home economics								X10	X10	X10	X10	X10	X10
Industrial arts								X11	X11	X11	X9	X9	X9
Moral education					X	X	X	X	X	X	X	X	X
Martial arts											X11	X11	X11

Figure 15-3: Simplified representation of the subjects required of typical Japanese students. (Source: Unks, G. [1992, December]. Three nations' curricula: What can we learn from them? NASSP Bulletin. Reprinted by permission of the author.)

Notes:
1 primarily instruction in reading and writing
2 primarily addition and subtraction
3 not distinguished as a separate subject; integrated into reading and writing
4 instruction begins at a simple, almost "play" level and progresses through the grades to ever higher skill levels
5 primarily multiplication, division, fractions, and decimals
6 algebra and some geometry are introduced
7 higher mathematics are introduced
8 elective course
9 offered only in special, technical high
10 only females are required to take this course
11 only males are required to take this course
12 only one year of this subject is required in the upper secondary school

(Sources: Iio, 1992; Yoshioka, 1992)

nology education may become a more popular and certainly a more relevant subject. Politicians would hope that enrolling in technology education would result in a more productive economic and successful population while educators would hope for future citizens who are better able to understand their environment and society and to make informed decisions.

International Events In Technology Education

Seminal research was initiated in 1985 at the University of Technology in Eindhoven, The Netherlands, by Jan Raat, a professor of physics, and his colleagues, Marc deVries, Falco deKlerk Wolters, Ilja Mottier, and others. Their research resulted in a project known as the Pupils' Attitude Toward Technology (PATT) project. As a result of this student-centered research effort, technology education in The Netherlands has gained global recognition and prominence. Their original research has been replicated in over 20 countries worldwide, including a major study in the United States by E. Allen Bame and William E. Dugger at Virginia Polytechnic Institute & State University (Bame & Dugger, 1989). Seven PATT international conferences in The Netherlands and regional conferences in Poland, Kenya, and the United States have been conducted to debate and discuss the progress and problems of technology education in various countries. The PATT researchers have provided an international forum for promoting technology education. Their research has been an important political catalyst in getting technology education as a required general education subject in The Netherlands. As a result of the PATT conferences and subsequent research, interest and work in technology education have been stimulated in many European countries, the former Eastern block countries, Africa, and in other countries throughout the world.

The United Nations Education, Scientific and Cultural Organization (UNESCO) is now actively involved with technology education through the leadership of Rafael Ferreyra from the Science and Technology Education Division at its headquarters in Paris, France. As an inter-governmental organization consisting of 159 member states, it conducted the Global Survey on the Place of Science and Technology in the School Curricula in 1984 (reported in 1986) and the International Symposium on the Teaching of Technology in General Education in December 1985. Accurate data from these surveys, unfortunately, are not available on technology education because of the ambiguity in the use of the term technology in the countries surveyed. In cooperation with other agencies, sectors, and organizations, the UNESCO continues to support projects and experiences that contribute to the clarification of the concept of technology education. The Science and Technology Education Division of UNESCO supported the International

Conference on Technology Education, which was held in Weimar, Germany in April 1992. The UNESCO also supported, in cooperation with major non-governmental organizations of science and technology educators, the World Conference on Scientific and Technological Literacy, which was held in Paris, France in July 1993. The Paris conference was a follow-up to the World Conference on Education for All, which was held in Jontiem, Thailand in March 1990. Political leaders and cooperative agencies throughout the world reached consensus in Jontiem about making coordinated efforts toward universal education, geared to the satisfaction of the basic needs of the less favored population groups. Technology education in schools and in non-formal contexts should have an influential role to play in this area in the future.

The World Council of Associations for Technology Education (WOCATE) was formed at the International Conference on Technology Education in 1992 in Weimar, Germany. It was established to work with the various worldwide groups, organizations, and associations that promote technology education. (A more comprehensive discussion of WOCATE may be found in Chapter 18 of this yearbook.)

The Organization for Economic Co-Operative Development (OECD), which is headquartered in Paris, France, has become actively involved in technology education within the past few years. The OECD sponsored a March 1990 conference on science, mathematics, and technology in Orlando, Florida and commissioned case study reports in each of these three areas. The OECD also sponsored a follow-up conference in France in November 1991 to map out a future program of research.

The International Technology Education Association (ITEA) has been actively involved in promoting technology education worldwide. This association, which is headquartered in Reston, Virginia, holds an annual conference at which a series of meetings that focus on international technology education are conducted. The ITEA also sponsors an international luncheon that usually includes a speaker from a foreign country. (A more comprehensive discussion of the ITEA may be found in Chapter 17 of this yearbook.)

INTERNATIONAL TECHNOLOGY EDUCATION

Organizational Structures of Technology Education

Technology has, as its origin, the altering of human condition. It is estimated to be over two million years old and has its roots in the desire and inventive powers of men and women to improve their lives by making human efforts more efficient. Technology is about designing and producing products, finding new and better methods of transportation, and determining how people can communicate more rapidly and accurately. Technology has revealed itself in many ways in our world over the millenniums, however, most of the technological knowledge and development has taken place in just the past few decades. It is little wonder, therefore, that the process of educating the masses about technology has evolved from many backgrounds and has taken many different forms in countries throughout the world.

The study of technology as a school subject is a relatively new endeavor. The background or form of evolution for technology education can be categorized in the following major evolutionary categories: crafts/*sloyd* heritage, vocational heritage, and academic heritage. The Scandinavian influence in *sloyd* or home handicrafts has provided a strong heritage for technology education in the world. The inherent ties with *sloyd* and arts and crafts make technology education appealing as a subject that every child should be exposed to and benefit from in his or her experience. The development of psychomotor abilities in the child also make *sloyd* appealing as a co-partner with cognitive and affective curricular offerings. The influence of *sloyd* should not be underestimated in the worldwide movement in liberal or general education.

The influence of vocational education on technology education can be traced to the Russian system of teaching mechanic arts devised by Victor Della Vos in 1868. Many people both within and outside of the profession, unfortunately, have had difficulty in separating the philosophical differences between vocational education and technology education. Countries like Germany, for example, are currently trying to evolve their technology education programs from a very strong vocational and apprenticeship heritage, and they are creating major differences in terms of purpose and content between technology education and vocational education. It will be interesting to monitor the progress of their efforts.

Since we live in a technological world, many people consider a study of technology as a component of academic or basic education that is essential for all students. This is especially true at the early childhood level (pre-kindergarten through primary school) and at the early secondary school level. Great Britain and The Netherlands are two countries, for example, that require the study of technology for all pupils. In certain other countries, technology education has evolved from the science community. Some countries view technology education as an excellent integrator of other school subjects such as mathematics, science, and social studies.

Goals and Trends

The goals for technology education in countries throughout the world vary considerably. In Third World countries, for example, technology education may be part of the program of appropriate technology that is taught as a means for economic and cultural development. In more advanced economic societies, however, technology education may be viewed as a means for increasing the economic position of a country in global competition. Atkin (1991) stated the following in the article entitled, "Teach Science for Science's Sake; For Global Competitiveness, Try Technology":

> The type of thinking encouraged by technology emphasizes variety and a certain divergence in intellectual effort. It is a type of thought and action seldom fostered in schools, yet it may have more to do with economic well-being than the subjects that currently dominate the curriculum. Technology, with its persistent focus on the relationship between mind and hand—with its insistence on practical work—seems closer than other subjects, including science, to the knowledge and skills necessary to improve the country's commerce and industry.
>
> But even if it weren't—even if there were not a robust link between a well-crafted technology curriculum and the country's economic well-being—a solid case could be made that technology should be included in elementary and secondary schools because the knowledge it embodies is important in its own right. Practical reasoning is a universal, productive, and distinctive human activity. Emphasizing it may have the desirable effect of helping students see clearer connections between the activities they are made to do in school and the issues that make a difference in their own lives. (p. 50)

Probably the best stated goals for technology education are found in a publication of the American Association for the Advancement of Science entitled *Technology, a report of the technology panel, Project 2061.* Johnson (1989) identified the goals as follows:

> Technology education should reveal the process of technology as it evolves ideas to fruition. This can best be learned using laboratory experiences to augment classroom instruction. Likewise, such education should show how technology affects individuals and society.
>
> Technology education should be appropriate to the student's age and experience. It should begin with descriptive material and then involve principles and concepts, incorporating direct experience at all levels.

> Technology education that includes social impacts as well as the technics provides the opportunity to integrate the two in newly formulated curricula, possibly making increased use of team teaching.
>
> The sciences and mathematics are important to the understanding of the processes and meaning of technology. Their integration with the technology education curricula is vital. (p. 3)

Trends in technology education are evolutionary and difficult to state in a new school discipline. Some obvious trends from a global perspective are the following:

- A closer alignment of technology education as an essential offering for all children.
- A growing kinship between technology, science, and mathematics.
- A viewing of technology by some as having the potential educational orientation in public schools for teaching engineering concepts and principles.
- A movement downward in the grades/ages in schools in the offering of technology education (i.e., primary/elementary school and pre-kindergarten/kindergarten).
- The need for research in what should be the most appropriate universal curriculum content for teaching technology in schools.
- The separation of technology education from vocational education, which has already occurred in some countries, and appears to be gaining momentum in others.

Curriculum Thrusts To Internationalize Technology Education

With the growing telecommunications evolution occurring today, is now possible to connect various cultures, schools, and individuals via computer, fax, and telephone. It is also possible through this technology to break down curricular differences that exist in various countries in the world. The movement toward national curricular and national curriculum content standards are additional efforts for countries to learn from each other. A good example is the National Curriculum in Great Britain, which is being studied by many countries for adaptation or modification. The current movement in the United States in developing curriculum content standards is having a major influence in other countries. The educational systems of

Japan, Taiwan, Germany, and other countries are being studied for their successes in student achievement.

Impacts and Influences on Technological Literacy Around the World

Politics and economic development in a country provide powerful reasons for having a citizenry that is both culturally and technologically literate and capable. Vaughn Croft, while completing a doctoral dissertation at Virginia Polytechnic Institute and State University in 1990, determined the characteristics of technological literacy for high school graduates. As a result of his research, he concluded that the contemporary age of technology requires more skills in literacy than that which the supporters of the back-to-basics movement were identifying. He stated the following:

> The idea that a society can exist in a technological age with no more literacy than the ability to read a little, write one's name, and count change is barbaric. Rediscovering the basics (in education) is not enough. Literacy now includes the competence to sort, analyze, and synthesize an array of information. In the future, the difference between the haves and the have-nots will be measured in terms of understanding technology or becoming technologically literate. (p.16)

The Honorable Robert B. Reich (1989), the current United States Secretary of Labor, authored an article titled "The Quiet Path to Technological Preeminence." In the article he stated that if a country wishes to gain (or return to) technological preeminence in the global workplace, it must do the following:

- Scan the globe for new insights,
- Integrate government-funded research and development with commercial production,
- Integrate corporate research and development with commercial production,
- Establish technological standards,
- Invest in technological learning, and
- Provide a good basic education to all citizens. (p. 47)

Secretary Reich goes further to state that "in addition to conveying basic skills, primary and secondary school curriculums must emphasize critical thinking—a capacity to identify problems, raise questions and find structure in apparent disorder—rather than the mere regurgitation of facts" (p. 47). This is an excellent testimonial for the implementation of technology education in whatever country is impacted.

Resource Utilization to Support Technology Education

Technology education must be viewed by any country as a long term investment for the future. Technology programs are not inexpensive, unfortunately. Up-to-date laboratories with relevant equipment and supplies are costly, as opposed to a traditional classroom with only chalkboards and student desks. When compared to other expensive areas in schools, such as athletics, there is no immediate visible return in investment, such as that which may be gained from the sale of tickets to an athletic event.

Many outstanding technology educators have developed close ties with those population groups in the community that are technological in nature. These relationships pay valuable returns in terms of financial and philosophical support. Many technology educators in countries throughout the world have become more politically proactive in order to gain support for their programs.

Organization Involvement

It appears to be possible in every country for educators to try to accomplish more by organizing together to gain support for the new school subject called technology education. When making important decisions, however, politicians, school boards, and governmental agencies always seem to pay more attention to numbers rather than individuals. Gaining support from professional associations of other school disciplines, such as mathematics and science, appears to be a wise move and one that should be promulgated. The UNESCO is but one prime example of technology education fostering support from science education.

The International Technology Education Association (ITEA) and its affiliated councils continue to provide support to technology education worldwide. The Technical Foundation of America (TFA) has been proactive in funding more international proposals, such as the recent joint TFA/ITEA/PATT International Conference on Technology Education: A Global Perspective that was held in Reston, Virginia in 1992. The PATT will continue to offer its biannual conference on a worldwide spectrum of key topics relevant to technology education. If technology education is to grow and flourish in the future, not only in the United States but throughout the world, it must be promoted and understood by all.

FUTURE DIRECTIONS

In the future, the technology education curriculum must be better researched and defined. Unlike many other school disciplines, technology education does not have an agreed upon curriculum content base. The disciplinary base for physics or calculus, for example, is about the same anywhere in the world. The identification of the intellectual domain or what everyone must know, have values in, and be able to do in technology must be further researched. The modes of inquiry and a research agenda in technology education as a discipline must reach a closure. An internationally recommended basic curriculum for technology education should be researched and developed.

The technology profession must become more politically astute in the future, if the profession is to position itself in a worldwide posture as an essential subject matter that prepares people for technological literacy. If, and when, the profession identifies its disciplinary base and sets standards to assure that the curriculum content is being understood and synthesized by every child in the world, then the identified goals will have been achieved to their fullest extent. The profession must also state its case for and receive quality fiscal and physical resources if technology education is to gain prominence as a viable subject matter that is basic and essential for all. More research needs to be conducted over a long term on whether technology education makes a difference in enhancing the economic competitive ability of a locality, state, or country. Furthermore, an all encompassing research agenda must be set from a global perspective if the profession is to realize its dreams about technology education. Internationally, government officials must take the initiative to provide support to the total effort of educating everyone about technology. Finally, professional groups and associations must pledge their ever increasing support to develop the educational structure for quality programs in every country.

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CHAPTER **16**

Technology Education Leadership

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Many people believe American education today is facing a leadership challenge. Unfortunately, there is little consensus regarding what is meant by the term leadership. Bennis and Nanus (1985) noted that "decades of academic analysis have given us more than 350 definitions of leadership" (p. 4). Everyone has his/her own personal definition of leadership, but to this author leadership in its most simple and yet powerful form is hope. The top leader whose success hinges on people skills is a merchant of hope. Hope is possible through the ability of people to make informed choices. Leadership, when practiced at its best, is choice making that enables people to turn their dreams into visions and visions into meaningful reality. What choice must technology education make to have a meaningful future? Many people believe it's leadership.

People the world over are fascinated by leaders, just as they are curious about what these leaders think, wear, eat, and the how of their success. Spin doctors cleverly promote their leaders through arranging appearances on talk shows, organizing public speeches, and appearing in various print media, including best selling autobiographies such as those of Lee Iacocca (1983) and Sam Walton (1992). The best selling leadership books are full of true stories about what happens on the road to success. Yet, in his influential classic entitled *Leadership*, Burns (1978) warned that "the crisis in leadership today is the mediocrity or irresponsibility of so many women and men in power. . . . The fundamental crisis underlying mediocrity is intellectual" (p. 1).

The future belongs to the informed—the knowledgeable organizations and workers (Drucker, 1993; Peters, 1992; and Senge, 1990). Workers and organizations must constantly learn and relearn if they want to stay competitive. A significant example of not staying competitive is found in American public schools. Today, public schools are facing one of the greatest challenges in their history. The general public and parents alike are unhappy with the public school system's performance. A lack of confidence has triggered the advent in America of the school voucher pay system.

There is considerable research to substantiate the premise that the difference between well-run and poorly run schools is the principal's leadership performance. The same can be said about any organization's top level management, whether that organization is in the public or private sector (Bennis, 1993; Drucker, 1993; and Peters, 1992). As it relates to technology education, the search for leaders must continue. As the profession examines the major problems facing technology education today, it must be concerned about what kinds of leaders it needs, where to look for them, and how to identify those people who have the potential to deliver leadership.

This chapter addresses four fundamental questions to provide support for the importance of leadership and, specifically, leadership in technology education.

1. What is leadership, its needs, power, and purpose?
2. What are the keys to leadership effectiveness?
3. What leadership knowledge has the profession produced?
4. What can be the leadership impact on technology education?

LEADERSHIP: ITS NEED, POWER, AND PURPOSE

Need For Leaders

Experts in the field of top performance very strongly point out that the call for leadership is one of the keynotes of our time. If we agree with the experts, then why did Deming give up on America and take his total quality management (TQM) process to Japan? The world is fully aware of what Deming's (1986) knowledge did for the Japanese people's productivity and their eventual rise in economic power. While Japanese success was occurring, American manufacturers stood idle and their built-in domestic market slowly disappeared. Why did it take so long for American producers to listen to Deming? A recent Gallup poll noted that 85% of America's company managers still fail to comprehend the significance and value of transformational leadership and the positive forces resulting from principles embedded in TQM.

If a spaceperson landed in the center of an International Technology Education Association (ITEA) annual conference and asked, "Who is your leader?" the membership would be hard pressed to reply to her/him. It would be even more of a formidable task for the Council on Technology Teacher Education (CTTE) to answer the spaceperson's question. We tend to overemphasize the part played by one leader because technology education has a legacy of people interacting in complex ways to provide basic leadership practices.

Technology education could accept a diminished emphasis on the role of a leader, however, to imagine the impact of a leaderless profession is to ignore several difficulties, as presented by Gardner (1990). First, if technology education teachers turned over their classroom leadership to students, the result would be chaos. Students want a leader, a parent figure, who in times of difficulty will be there to assist them. Second, there are circumstances in which a group cannot function as well as when there is an individual leader. The leader's role could take on the nature of a servant first as outlined by Greenleaf (1977) in his book, *Servant Leadership*. It is incorrect to say simply that the servant first leadership concept works. Many people agree that overusing the servant first concept could result in a leaderless situation. Third, the leader at times must rescue an individual from the group, due to peer pressure exerted on the person. Those who are hostile to leadership typically assume that coercion always comes from above. Research studies show, however, that peers directly or subtly are much more harsh on their colleagues' behavior than administrators are. Finally, and perhaps most importantly in organization performance, is the misplacement of power. When people take away power from an individual or group they dislike, they may end up giving it to others they like even less. The result is a leaderless chaotic situation. The passion to prevent the abuse of power may make leaders the targets of hostility, diminish their stature, and strip them of power.

Power of Leadership

Campbell (1984) noted that "leadership is a heavy experience because it involves power" (p. 121). It is power and the use of power that drives certain people into leadership roles. Power by definition is simply the capacity to bring about certain intended consequences in people's behaviors (Gardner, 1990).

A common dichotomy of power is that some people vigilantly chase it with a passion while others despise its very existence. Why this paradox about power? Perhaps it is because during the last century, the world could not escape the horror of power, yet tolerated its abuses to win over aggressors. The atrocities of Joseph Stalin and Adolph Hitler dominated our thoughts, while Winston Churchill and Franklin Roosevelt countered with their version of power—leadership. Recently, the abuse of power showed its ugly head again when Saddam Hussein, who wanted more land, caused others to use a counteraction known as Desert Storm.

Other more subtle ways of exerting power are forever embedded in our memories. Examples include the department head who withheld merit pay to penalize a faculty member and the school principal who was reassigned because he was not liked by the district's superintendent. There was also the school administrator who feared so much for the loss of power that he turned to an exploitive and manipulative scheme to regain control.

Typically, power/leadership potential comes with position. The degree of power may at times, however, not be realized or understood by the leader. While once visiting with a new college dean, the author asked him how he was doing. He said, "I didn't know or realize just how much power I have." An interesting concept of power is that the perception of it is often greater than the actual power held. Reality strikes when the leader and follower enter into a conflict and power or potential power is used. Perhaps the old truism fits: power used is power lost.

The positive side of power is evident in all human relationships. A leader could not lead without power because there would be no followers. Accomplishing goals, solving problems, gathering information, and making decisions all require power. At every level, a fair distribution of power must be provided if the highest human potential is to be achieved. To prevent abuse, leaders must be held accountable for their actions. Hogan, Raskin, and Fazzini (1990) noted that 60 to 75% of the managers in the United States are incompetent and that incompetence has become a primary source of stress and unhappiness for a majority of workers. Burns (1978) stated that power comes from control of three elements: (a) motives and resources of power holders, (b) motives and resources of recipients, and (c) the relationship among all these.

The popular buzz word for effective leadership is empowerment. It is a word that describes the effective leader's appropriate distribution of power, authority, and influence. The empowerment paradigm occurs when power-making decisions are moved to where the information is located. In the same context, decentralization of power involves all members of an organization in the decision-making process. The power down concept is possible only if people are trained to understand and use knowledge for an organization.

A word of caution should be noted by those who seek power: it can be self-destructive. Perhaps the most familiar aphorism about power is Lord

Acton's assertion that, "power tends to corrupt; absolute power corrupts absolutely." Stern (1979) noted that "power is like any narcissistic behavior; it becomes addictive. As we move up the ladder of success, we want increased dosages" (pp. 13–14).

The use of power and the results from its usage are very descriptive. Take, for example, a school principal who uses her power to get rid of teachers who cross her. One process that may be used involves assigning the most disruptive children of one grade level to the teacher in question. The principal thus intimidates the teacher through sophisticated negative colleague and parent comments. Dealing with the situation and classroom disruption may create stress, loss of self-confidence, and general deteriorating health that ultimately ends in a resignation from the teacher.

At another school, the principal empowers all teachers to become the best they can and she provides total support for them. A technology teacher educator tells the story of a colleague who drives 75 miles a day to teach in a specific school. The colleague had an opportunity to change positions to a school within one mile of where he lives. He turned down the opportunity because he loved his current position. The teacher said that the principal at his school is one of the best persons he had ever worked for, and that all the teachers work together to make teaching a joyous event. Finally, this teacher stated, "I get up every morning looking forward to going to work."

There are all types of people who assume leadership positions. Some fail as the assignment of power corrupts their attitude and personality. Perhaps Gardner (1990) said it best: "It is a source of constant wonder that such an ancient and dreary vice [power] can spring up so freshly. It takes only moments for intoxication of power to take hold" (p. 66). Most people have observed a person they know who took on a new leadership position. At first the person was just as before, then slowly the individual changed and eventually became addicted to power seeking. A better way for improvement is through leadership training and development.

Purpose of Leadership

The purpose of leadership might best be communicated in a story told by Max De Pree (1989). In the 1920s, furniture production machines were driven by belt pulleys from a central drive shaft. Power for the drive shaft was provided by a steam engine that got its steam from a nearby boiler. Sawdust and scraps from the machine room fueled the boiler that powered the steam engine. The result was a superbly efficient cycle.

The key person in the Herman Miller furniture factory was the millwright, whose assignment was to oversee the entire operation. One day the millwright died. The young manager of the furniture factory thought it appropriate to visit the millwright's family. The widow invited him into the living room and after a period of awkward conversation, the widow asked if it would be all right for her to read some poetry. The young manager agreed. She went into another room and came back with a bound book from which she read selected pieces of poetry. When she finished, the young manager commented on how beautiful the poetry was and asked who wrote it. She replied that her husband, the millwright, was the poet (De Pree, 1989). Max De Pree, son of the young manager and the Chief Executive Officer of the famed Herman Miller furniture corporation, said, "Was he a poet who did millwright work or was he a millwright who wrote poetry" (p. 9). Certainly, every human being has special gifts and talents that the typical manager might not know.

The story of the millwright illustrates two vital leadership points for technology education. First, leadership begins and ends with people. The effective leader understands and values the fact that all people have diverse interests, motives, and desires. The best leaders are able to discover and use the special gifts, talents, and skills of each person in the organization.

When the leader recognizes and uses diversity, it provides meaning, fulfillment, and purpose of life to all people in the organization. Burns (1978) added a poignant comment about the moral foundation of leadership in the organization. He stated that "we will consider as truly legitimate only those acts of leaders that serve ultimately in some way to help release human potential now locked in ungratified needs and crushed expectations" (p. 5). The secret to technology education's future success lies in its leaders and/or teachers taking advantage of the whole person. Kanter (1983), in her profound book entitled *The Change Masters*, noted that leaders must learn to "take advantage of the talents of the people and . . . begin to treat people as contributing individuals rather than an anonymous mass whose primary role was fitting into the slots the company had made available" (p. 357).

Max De Pree's father started a legacy at the Herman Miller furniture factory when he showed an appreciation for the dead millwright by visiting his family. That small beginning demonstrated a concern for people and their diversity and helped elevate the furniture corporation to be named one of *Fortune* magazine's 10 best run companies and to be listed as 1 of the 100 best companies to work for in America. How important is it to be appreciated? Schwartz, (1983) surveyed 6,600 people from all walks of life, levels of education, ethnic backgrounds, and geographic areas in the United States and Canada and found a surprising answer to two questions. First, over 97% stated they did not receive as much praise, approval, and appreciation as they thought they deserved. Second, over 98% stated that they would perform their jobs better if they received more praise, approval, and appreciation. How would technology educators respond to these two questions?

The second point about the millwright story involves change in technology. Today, each machine has its own power. The evolution from the central drive shaft configuration to an individual powered machine took numerous technological efforts and expertise. Similarly, over the years, technological progress has been made through organizational performance of persons in a group. Drucker (1985) stated that increase in productivity would not come about by using the traditional process of gaining faster and faster machine outputs, but through the technology of increasing individual and group performance. In order to do this, as well as to meet global competition, America is beginning to practice such new management techniques as TQM and a host of other new and reoccurring leadership systems and processes.

De Pree (1989) summarized the discussion about the millwright by stating the following: "When we think of leaders and the variety of gifts people bring to the corporations and institutions, we see that the art of leadership lies in polishing and liberating and enabling those gifts" (p. 10). In essence, the present and future power of leadership for technology education is linked to the leader's ability to harness the talents, gifts, and motives of all people in the profession.

LEADERSHIP: WHO PARTICIPATES IN IT?

Contrary to popular educational thought and supported by a vast array of evidence, an organization's leadership comes from all people in the organization. At times the leader leads and at other times she/he follows while others do the leading. One of the chief purposes of a leader is to teach others to lead. Several years ago, this author was seeking participants for one of the three week-long leadership development symposiums sponsored by the International Technology Education Association. The author was attempting to persuade a local classroom technology teacher to attend the symposium. His response was that he was just a teacher and not an administrator, so he didn't need leadership training. More alarming was the teacher's statement that he felt intellectually inadequate to learn about leadership. What a myth this technology teacher held for his leadership importance in the profession!

Evidence by selected leadership experts (Bennis & Nanus, 1985; Burns, 1978; Drucker, 1989) has shown that good leadership is good teaching and good teaching is good leadership. Why are leadership and teaching so closely related? First, the principles and practices of leadership are directly related to the characteristics of master teachers. Second, through an examination of the recently evolved definition and purpose of leadership, a similarity between master teachers and successful leaders is found.

DEFINING LEADERSHIP

Leadership is puzzling and is one of the most talked about, yet least understood, phenomena in society. Cronin (1984) believed that Americans yearn for leaders for their communities, companies, military, unions, universities, sports teams, and nation. He went on to say, "We love great leaders but not power wielders" (p. 22). Although a leader has been described as a merchant of hope, a closer and more in-depth examination is needed in this chapter.

The question is, then, what exactly is leadership? Recently in a *Wall Street Journal* cartoon, two men were talking about leadership. Finally one turned to the other in exasperation and said, "Yes, we need leadership," and the other person responded, "Yes, we need someone to tell us what to do." Leadership can be like a prickly weed that tends to hurt anyone who touches it or like a beautiful flower that adds an uplifting aroma and fills its space with charm. The meaning of leadership may not be clear and concise, but we all know the difference between when it happens at its best and at its worst. Perhaps it is appropriate to define what leadership is not. The points in Figure 16–1 were gleaned from the literature regarding what leadership is and what it is not.

The points in Figure 16–1 provide an awareness of what leadership can become if it focuses on results through people. Listed below are several popular definition statements of leadership:

- Achieving mutually set goals and objectives.
- Getting things done through others.
- Helping others accomplish things that they would not do otherwise.
- Performing set duties or acts based upon a contractual arrangement.
- Elevating followers to achieve a set action.
- Sharing images of the future.
- Changing or innovating.

Burns (1978) identified two forms of leadership: transactional and transformational. Transactional leadership occurs when a person seeks out others for exchange of some valued item(s). A bargain is struck between the leader and follower to achieve a mutual benefit that may be economical,

Leadership Is Not	**Leadership Is**
Bossism	Empowerment
Power wielding	Power enabling
Analysis and planning	Visionary dreaming
Control and demand	Openness and freedom
Things oriented	Others oriented
Failure prevention	Failure utilization
Imposing sanction	Cheering and uplifting
Committee work	Task force
Present focused	Future focused
Small ideas	Vast thinking
Leader first	Servant first, leader second
Contractual	Morally uplifting
Stability holding	Liberating and enabling
Single	Collective
Authority by position	Authority by knowledge
Mean spirited	Inspiring

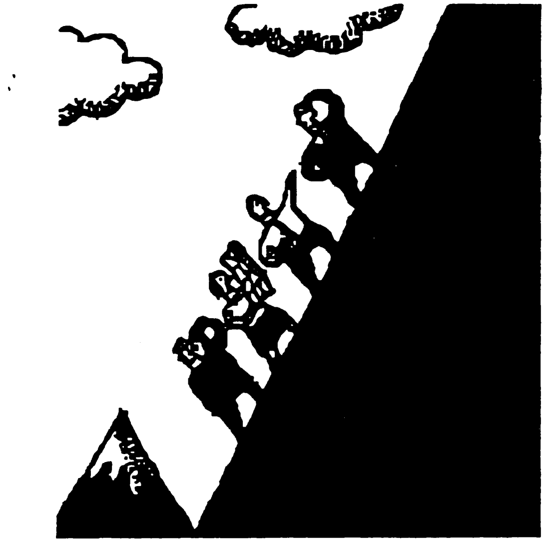
Figure 16-1: The contrast between what leadership is and what it is not.

political, or psychological. Typically, it is a contractual process that is either formal or informal. By contrast, transformational leadership happens when the leader/follower interaction results in mutually raising each other to higher and higher levels of motivation and/or morality.

Adding to the transformational concept is Greenleaf's (1977) argument that "the great leader is seen as a servant first" (p. 7). The person who first seeks power usually fails to realize it. The transformational process emerges through the natural feeling that one really wants to serve others. Waitley (1982, 1983) stated that to gain the true feeling of serving others, one must plant shade trees under which one will never sit and for which one will never receive any recognition. Greenleaf (1977) outlined the two practices when he stated the following:

> The difference manifests itself in the care taken by the servant first to make sure the other people's priority needs are being served. The best test, and difficult to administer, is 'Do those served grow as persons? Do they, while being served, become healthier, wiser, freer, more autonomous, more likely themselves to become servants'? (pp. 13–14)

The evolving definition of leadership can be viewed by the following statements from the Center of Creative Leadership (1992).



You can hand your staff a map and tell them to go to the mountain top. Or you can give them boots, a compass, the desire to climb—and an invitation to come with you.

Figure 16-2: Leadership. (The Forum Corporation Special Report, *1990. Illustration by Kaczman, J., 1990)*

- FROM: Leadership is a process in which the leader influences followers to do something.
- TO: Leadership is an interaction process between leader and followers working towards a shared purpose.
- AND NOW: Leadership is making meaning in collective experiences.

Cronin (1988) stated, in a speech to a group of educational administrators, that education has not moved beyond the dominant practice of transactional leadership. It is only logical and fitting that educators who are in the helping profession should move toward incorporating the transformational process. Perhaps this helping concept can best be understood by examining the illustration from The Forum Corporation's (1990) report on leadership, as shown in Figure 16–2.

Burns' (1978) concept of transformational leadership is one of the most widely accepted and used definitions today. When Greenleaf's servant-first idea is added, the evolving definition of leadership has the potential to shape the destiny of technology education. At this point, one is reminded of the old adage that a little bit of information is dangerous. Tom Peters seemed to agree, when he stated in his 1992 book entitled *Liberation Management*, that it took him 30 years of intense study, research, writing, and presenting before he began to grasp the reality of management-leadership and what it means to become a successful organization.

KEYS TO LEADERSHIP EFFECTIVENESS

Leadership can profoundly increase performance in any endeavor as Kenneth E. Clark, a noted expert on leadership, agreed. He stated in a telephone interview (Wenig, 1993b, August) that "a top leader can increase an organization's performance by at least 20%." Most people would agree with this after examining the records of the great leaders of the past. In whatever field or occupation, they did make some kind of difference. Major (1986) noted that just thinking like a leader has a positive effect on performance. He found that high school principals who described themselves as behaving like leaders are in the same schools where evaluation indicated that students learn more and drop out less. The next question is, if we know that leadership can make a difference, do we know if it can be predicted?

Predicting leadership success is at best very difficult because of many controlling variables. Clark and Clark (1994) identified three longitudinal studies that provide evidence of the early predictability of identifying top executives. The three studies were (a) *The Exxon Study* by Sparks (1990), (b) *The Sears Study* by Bentz (1990), and (c) *The AT&T Study* by Howard and Bray (1993). The critical predictor factors identified in these three studies were (a) intellectual ability, (b) personality, and (c) personal history. Perhaps the bigger question then is, does hard research exist to provide evidence that common leadership qualities can be found in top leaders?

Common Leadership Qualities

It would seem to be a simple exercise to be able to identify common leadership qualities by observing and interviewing top leaders. This type of research, however, is seriously flawed. The problem is that when researchers rely only on the results obtained from interviewing leaders, they merely witness the behavior of themselves and the leaders' abilities to sell their worth. The best practice is for researchers to collect data from followers/subordinates, superiors, and the leaders themselves, thereby providing three different perspectives. There are also other factors that must be considered when measuring the common qualities of leadership. For example, the environment or setting in which the leader performs and whether the sector is public or private is important to consider. Another factor is the level of leadership responsibility. Even so, responses from selected experts (Bennis, 1993; Drucker, 1993, Kouzes and Posner, 1987; Wenig, 1993b, August) agree that there are common leadership qualities that can be identified.

A number of research studies that address the common qualities of leadership have been conducted. Six of these studies are reported in this chapter. The first research study was conducted by Kouzes and Posner (1987). They wanted to determine what leaders did when doing their personal best at leading, not managing, so a Personal Best Questionnaire was developed. The instrument consisted of 38 open-ended questions that were used to identify common practices of successful leaders. They collected data on middle and senior level managers from both private and public sector organizations. Their results produced five common essential characteristics of leaders.

1. Challenging the process.

   a. Through the love of change, leaders seek and accept the challenge to test their ability. They look for innovation to motivate the organization.

   b. Leaders experiment and take risks. They treat failures as learning opportunities.

2. Inspiring a shared vision.

   a. Leaders look forward to the future by holding in their vision the ideals of what can be. They also believe that people can make a difference.

   b. They enlist others by breathing life into the vision. They communicate their hopes and dreams so others can clearly understand and accept the vision as their own. Using quiet persuasion and strong appeals, the leader builds support.

3. Enabling others to act.

   a. Leaders foster collaboration through team building in "it's a family atmosphere." They actively involve others at the start by being considerate of others.

   b. They strengthen others through building self-esteem to create an atmosphere of trust and human dignity.

4. Modeling the way.
   a. The leader sets the example through modeling the best behavior. The leader helps set high standards to build an organizational culture that is unique and productive.
   b. Leaders plan small wins. They set the agenda so all may be successful, which in turn builds better self-esteem.
5. Encouraging the heart.
   a. Getting to the top requires hard work. The leader inspires and encourages continuance towards the goal. The leader gives recognition to people's contributions with a thank you note, a smile, an award, or public praise.
   b. The leader celebrates the accomplishments of others, takes pride in telling all about the organization's accomplishments, and makes people feel like heroes. In order to do this, leaders are in love with people and sense joy in seeing others achieve.

These five characteristics of leaders place emphasis upon enabling others to reach their own and the organization's shared objectives. When the leader takes heart in working through others by using the five leadership behaviors, the organization transforms to the highest performance level.

Kouzes and Posner later developed the Leadership Practices Inventory from an analysis of the personal best cases. The inventory resulted in a model of leadership. The findings from this instrument were used to build training programs based on the five essentials to increase leadership competence.

Bennis and Nanus (1985) found four essentials that make leaders successful. During a 5-year period, they spent time with 90 of the most effective and successful leaders from both public and private corporations and organizations in the nation. Bennis and Nanus sought to determine the common core of leadership qualities among their 90 subjects. They stated that true leaders are

> people who affect the organization's culture, who are social architects, and who create and maintain values. Leaders are people who do the right thing while managers are people who do things right. Simply both roles are needed but, differ significantly. A key problem facing American organizations is that they are over managed and under led. (p. 78)

Clark and Clark (1994) are critical of the Bennis and Nanus information-gathering process for the data were obtained from just the leaders' points of view. (Later they sought information from subordinates.) Clark and Clark believe that leaders and managers cannot realistically judge their own actions and tend to sell their values as they did their organization.

Bennis and Nanus (1985) and Bennis (1993) identified the four common leadership strategies that all top leaders possess: (a) attention through vision, (b) attention through communication, (c) trust through positioning, and (d) development of self through self-regard. The leader who uses the four leadership strategies will empower others to reach their fullest potential.

Bruce (1986) interviewed retired CEOs of 13 Fortune 500 companies who had had lengthy stays as the top executive in their corporations. The purpose of his study was to determine what leadership qualities these CEOs said they had utilized in order to be successful. He concluded the following five qualities were fundamental:

1. Be consistent in all actions with others.
2. Set the tone of the organization through a positive modeling behavior.
3. Decide the direction (vision) of the organization through assessing internal and external events, situations, and happenings.
4. Feel the need to move the organization ahead; a step to changing the environment and setting the future.
5. Involve followers to help refine critical decisions.

Kotter (1988) studied the ability of corporate leaders to accomplish change. His investigations started with interviewing 150 CEOs representing 40 different firms. He also obtained responses to a 10-page questionnaire from 1,000 top leader executives and examined 15 corporations with good reputations. Finally, he observed over a 3-year period five corporations involved in organizational change. The results of his research are as follows:

1. Create an agenda for change.

   This starts with a vision of what can and should happen involving all stakeholders. It also sets a strategy for achieving the vision.

2. Build a strong implementation network.

   Build a cooperative relationship with key power people in order to gain compliance and teamwork.

The fifth research project examined the work of The Forum Corporation, an organization committed to conducting research in leadership. Since 1971, The Forum Corporation has conducted investigations on specific leadership practices that distinguish highly-performing leaders. Over time, The Forum Corporation has established a vast database of leadership practices. The investigations have included such research methods as interviewing, surveying, focusing groups, and practicing experiences of their clients in a broad range of industries worldwide. Even though the research was conducted in the industrial sector, the results are appropriate because leadership effectiveness qualities are common across all sectors of society. The purpose of their research was to determine effective leadership characteristics in the middle to senior levels of an organization. Their research proceeded in three phases. In the first phase, 2,000 key leadership and management practices were analyzed from which the following three primary qualities were identified: (a) taking personal responsibility for initiating change, (b) creating a vision and strategy for an organization, and (c) trusting and empowering others.

The second phase identified specific practices that distinguish low- from high-performing leaders. Data were collected from interviewing the leaders themselves, as well as their peers, subordinates, and superiors. There was also a thorough review of the leadership literature to gain the consensus of key thinkers in the discipline. The third phase involved a comprehensive validation study. It provided empirical evidence that supported the accuracy of the previous findings.

The Forum Corporation's 20 action practices of leaders are summarized under four major topics:

1. Interpreting. The first set of actions helps leaders interpret the conditions, internal and external to their organization, that affect them and their people.

2. Shaping (visioning). These action practices help leaders shape a vision and set positive strategies to give meaning to the followers.

3. Mobilizing. This process enables the leader to gain support of individuals who possess different ideas, skills, and values, so a common mission or goal can be established.

4. Inspiring. The leader practices actions that motivate others to achieve intended results.

The Forum Corporation's research is impressive, as it is one of the most powerful and far-reaching investigations of all leadership quality studies.

Competency	Skills
Self-confidence	Self-presentation skills
Use of oral presentation	Verbal presentation skills
Logical thought	Organization of thought and promotion of sequential thinking
Conceptualization	Patterns identification through concept formulation

Figure 16-3: Leadership cluster competencies and skills. (Adapted from R. E. Boyatzis, 1982. The Competent Manager. *New York: John Wiley & Sons.)*

Boyatzis (1982) conducted a study to determine which characteristics of managers/leaders are related to successful performance in various management jobs in a variety of organizations. Basically, his attempt was to identify common competencies of people in leadership roles. The research resulted in a Job Competence Assessment Model and included identifying management clusters. The clusters were (a) goal and action, (b) leadership, (c) human resources, (d) direction of subordinates, (e) focus on others, and (f) specialized knowledge. The leadership cluster focused on the activation of human resources for the purpose of stimulating people productivity, as shown in Figure 16–3.

Boyatzis stated that to lead effectively, to represent the organization, and to inspire others, the leader must be able to do the following:

1. Identify the common objectives, values, themes, patterns, and mission of the people and groups in the organization.
2. Present one's self convincingly.
3. Communicate ideas, themes, and patterns to others.
4. Comprehend how the various parts of the organization affect one another.

Boyatzis' research is more than 10 years old and a whole new leadership-management revolution has taken place since the study was initially conducted. Regardless, the leadership cluster as well as the other five competencies provide data that fit the evolving definition of leadership. Evidence from this research adds weight to previous investigations on mission setting or visioning, communicating that vision, and positioning the vision to build understanding and trust with the various stakeholders in the organization.

As one reviews the literature of key thinkers in the field of leadership, such as Bass (1985), Bennis (1993), Bennis and Nanus (1985), Burns (1978), Clark and Clark (1994), De Pree (1992), Peters (1992), and Zalesnik (1977), to name a few, they all state that leadership is different from management. They believe leadership is a function of change that includes establishing a vision through input from others, communicating that vision, and providing an environment that will inspire and motivate people to overcome any obstacles. Management, however, typically deals with things that are vital to organizational structure and operation.

Leadership Styles

The Forum Corporation (1990) reported that leadership styles are of little value since leadership is based on a set of observable behaviors that persist from situation to situation or sector to sector. What specific behaviors does a person need to lead successfully in various situations, that is, from a highly structured task orientation to a highly open and free environment? In order to provide a basic understanding of leadership styles and situations, a review of literature was conducted. The managerial grid looms prominently in the study of early leadership situations and styles. It began with The Ohio State University studies of leadership behaviors in the 1920s. Previous thoughts about behavioral traits of leaders were losing favor at that time, since they were not fruitful for improving leadership effectiveness. After extensive study, there emerged leadership behaviors on a two-dimensional grid: consideration of people and initiation of task structure. If nothing more, the two-dimensional concept changed the direction of leadership study from stressing personal traits to stressing leadership behaviors. The management grid focused on identifying the appropriate behavior needed by a leader as the situation varied between people and task work events.

The application of this concept might follow this pattern. One may assume that a new employee or unskilled person requires attention from the leader or manager. What type of behavior would allow this person the greatest productivity? The management grid indicates that this person would require high task structure or direction to be effective on the job. At the opposite end, consider what type of leadership behavior would be appropriate for the employee who has considerable job experience and skill. The best in this situation would be more freedom by the worker to make her/his own decisions as long as performance meets expectations.

Fiedler (1967) indicated that leaders perform best when the leader's style or motivational patterns are appropriate to the degree of control (task) and influence (people orientation) that the leadership situation provides. It is imperative that leaders know and understand their own leadership style in order to avoid clashes between style and situations. Fiedler developed an instrument, called the Least Preferred Coop-Work scale (LPC), that determines a person's leadership style on a continuum from total task to total people on the management grid. Low scores indicate a leadership style of high task orientation, while high scores identify a leader's style that relates best to people orientation.

Hersey and Blanchard (1988) built a model to guide a leader to the desired needs of subordinates. They believed that the best leadership style is built by altering self-style to meet the situation. Leader success is then contingent upon a match between the specific person or group and the situation. Again, task versus people relations was the focal point of determining the best leadership style needed to be a successful manager/leader.

The widely known MacGregor (1960) leadership model of theory X task focus and theory Y people orientation became a highlight of leadership theory and practice. This two-dimensional model became popular for it seemed so simple to state. Research studies, however, have provided little evidence to support MacGregor's assumptions.

The most widely used and perhaps the most systematic model of the managerial grid and situational leadership theory was developed in 1964 by Blake and Moulton. Their two dimensions of the grid are (a) concern for production and (b) concern for people. The matrix of attitudes range on a scale from one to nine for both grid dimensions. The best behavior for the leaders was both highest task and highest people orientation (team management) or 9, 9 on the grid. A 1, 1 manager exerts little or no effort on each grid dimension. A 1, 9 manager on the grid would provide the highest people orientation and the lowest task completion focus.

What is much more powerful than the managerial grid is the evolving concept of transformational leadership. Jaques and Clement (1991) stated that the organizational leader must value the individual, promote his/her development, and generate mutual trust and confidence through gaining shared values, commitment, and support. The leader who fails to lead or take responsibility for her/his acts creates follower chaos. If a leadership vacuum or gap exists, all types of unethical possibilities emerge from followers.

A number of studies have indicated that a leader's responsibility is vast and complex (Clark & Clark, 1994; De Pree, 1989, 1992). Seven responsibilities common to all leaders were identified:

1. Handling all types of tasks.
2. Expanding and adjusting the vision.
3. Assessing the process constantly.
4. Resolving conflict.
5. Responding to altered circumstances.
6. Maintaining harmonious groups of followers.
7. Defining reality to give meaning to actions.

In addition to these seven responsibilities, the leader must balance her/his professional commitments and mission with personal values and self-interest.

Visioning

Common leadership qualities have been previously identified in the chapter and most can be learned through study and experience. The skill that seems to be most difficult for leaders or any person or organization to acquire is how to identify that powerful and elusive term known as vision. Stimulating and persuasive people have become leaders over the years by telling passionate stories or visions about possible futures. Two examples of visioning were provided by Martin Luther King, Jr.'s, "I have a dream" speech and John F. Kennedy's pronouncement that "We will place a man on the moon." In both instances, the masses were mobilized to act upon the speakers' visions.

Further justification of the need for and explanation why a vision is vital to anyone who wants to lead has been expressed by numerous people. Baker (1992) convincingly pointed out, in his impressive video tape program entitled "The Power of Vision," that we ought to be concerned about the future ". . . since that is the place where we will spend the rest of our lives." He expertly reviewed the research of three proponents of vision setting. One of the authors studied was Victor Frankl, the prominent Jewish psychologist who survived the World War II Nazi Germany concentration camps. In his 1993 book, *Man's Search for Meaning*, Frankl studied people who had survived the gas chambers in death camps. He asked, "What was the common thread as to why some survived and others didn't?" He discovered that the common thread among the survivors was that they had something significant they wanted to do after the war. The survivors had envisioned a powerful positive future that enabled them to overcome the most horrible of all human conditions.

History is full of leaders who were able to identify a vision and win consensus through input from followers and others, in order to redefine and/or to refine their mission. One may ask, can all people and organizations identify a vision? Certainly, anyone can make a statement and say that it is a vision. Regardless, two models that this author has personally taught and used with success in various groups are outlined below.

The first visioning process model is found in the audio tape entitled "Discovering Your Mission." Gerling (1990) identified seven steps that will lead a person to discover his/her vision:

1. Tapping your inner passion/love.
2. Envisioning your core values.
3. Steering in a future direction.
4. Adding sensory rich detail.
5. Stepping into that vision journey.
6. Relating vision to present situation.
7. Committing daily to vision purpose.

The second vision-building model was graphically developed by the author and comes from the 1986 tape entitled "The Visionary Leader" by SyberVision. It is based on the popular book by Bennis and Nanus (1985). The visioning process here has 11 steps that will enable individuals and organizations to determine their vision. It incorporates an array of dynamic participant activities that are directed through a vivid explanatory narration. The initial three steps enable the participants to examine the past, present, and future in order to identify strong declarations and assertions. The next four steps help them to determine their grand purpose by wishing and dreaming about the future. The final four steps provide each participant with the means to transform her/his grand purpose into a sensory rich vision, using colored illustrations and key terms and phrases. Participants have found the visioning process a rewarding and emotionally stirring event that works in producing a powerful vision.

LEADERSHIP IN TECHNOLOGY EDUCATION

Unfortunately, there is considerable evidence to indicate that technology educators have little or no interest in leadership development. Yet, experts in the subject of change and future success state that the most important and useful tool for change and the future success of technology education is found in possessing greater knowledge and skill in leadership. Why, then, does the problem exist? Perhaps it is because the profession in general has not felt the need, value, or worth of leadership development. In fact, graduate students interested in the topic of leadership must normally take such courses outside of the discipline. In order to address the issue of leadership in technology education further, a survey of the teacher education profession and a review of the technology education literature were conducted by the author.

Leadership Survey

A survey instrument was constructed, pilot tested, and revised using accepted measurement procedures (Wenig, 1993c). A stratified sample (college or university administrators at different levels, professors from different ranks, women and minorities, plus members of the ITEA Board of Directors) of the population included technology educators from all 50 states. Twenty-five respondents returned the survey instruments.

In the first question, the population was asked to identify the specific leadership knowledge and skills they had received and used over the past 10 years. Answers show that formal leadership training and development were achieved through attending such activities as TQM and NCATE workshops, serving as a department chair, and attending stress management workshops. Informal training included consulting, departmental administration of various types, and professional association work. When examining the formal and informal training that was received, it appears that the surveyed subjects obtained most of their leadership training from on-the-job experiences. In addition, they used words such as motivation, vision, influence, empowerment, setting direction towards a common goal, inspiring others, and teamwork to define leadership. It appears from the data that those subjects who have responsibility for leadership read the literature on leadership for the purpose of improving their knowledge and skills.

The second question focused on how the subjects characterized the present status of leadership in technology education and its performance in achieving stated goals and objectives over the past 10 years. Positive comments about the profession's leadership performance were that technology education has (a) made more progress during the past 10 years than at any time in its history, (b) worked very hard to transform its image from industrial arts to technology education, (c) provided excellent goals through the Professional Improvement Plan, and (d) established strategic planning as a positive force. Negative comments from respondents were that the technology education profession has (a) met the wrong goals, (b) placed limited emphasis on the needs of minorities and women, (c) developed a "good old boys" organization, (d) not provided room for the younger members of the profession to have much of an influence, (e) not addressed the future growth and development of the professional associations, (f) not addressed the closing of university technology education programs, and (g) not developed a shared vision.

The third question attempted to assess the leadership knowledge being produced by the profession. The results indicated that the leadership knowledge being produced was minimal. The ITEA's Professional Improvement Plan and its Leadership Development Symposium were identified as positive contributors to leadership resources and development.

The fourth question identified leadership qualities commonly associated with technology education's top leaders. The qualities that surfaced the most frequently were as follow: professional commitment, ability to gain a shared vision, communication through speaking and writing, teaching excellence, unselfishness, letting others take the credit, knowledgeability, honesty, industriousness, ability to persuade others regarding the reason for change, knowledge of how to empower others, organization, persistence, good listener skills, creativity, highly developed interpersonal skills, and positive attitude and scholarly thinking. These qualities taken together can provide focus in conducting leadership development activities.

The fifth question identified the leadership training and development efforts that have taken place within the profession during the past 10 years. The respondents identified only two specific leadership improvement efforts: Epsilon Pi Tau's 2-day leadership improvement programs in 1984 (Columbus, Ohio) and 1985 (San Diego, California) and the ITEA's Leadership Development Symposiums in 1985, 1987, and 1989.

The sixth question asked the respondents to assess or measure leaders and leadership in the profession. The most difficult problem, when assessing top leaders or leadership, is how to gain the most valid and reliable data. The results provided 25 different ways or means of assessing leaders and leadership in the technology education profession including, but not limited to, (a) ability to plan and implement change clearly, (b) commitment to the profession, (c) ability to develop and win approval of a vision, (d) total number of followers, (e) degree of student influencing, (f) level of knowledge production, and (g) ability to provide insight about the profession clearly to outsiders.

The seventh question attempted to identify those professional organizations that had made the greatest contribution to advancing the technology education profession. Ten associations were identified by the respondents, with ITEA being the one most often listed. Many of the respondents felt that all associations provide at least some support, with state associations being vital to the improvement of technology education. Many also felt that ITEA and Epsilon Pi Tau need much stronger leadership if they are to deal with the future effectively.

The eighth question focused on the most important leadership knowledge and skills needed by technology education and on how to increase the number and quality of leaders both in gender and race. Most of the respondents' remarks dealt with the need of a vision or gaining a shared value or vision for the profession. Emphasis was also placed on the ability of technology education to communicate and persuade effectively with outsiders in sharing the value and benefits of the discipline. Furthermore, respondents wanted leaders who could plan and implement change with appropriate models. They wanted young professionals, women, and minorities to have opportunities for leadership development. One person said, "We need to take people on a heroic journey, only then can we make progress that will be long lasting." The respondents wanted many more leadership development opportunities through a variety of delivery systems. They also wanted the profession to conduct research on what leadership behavioral characteristics and qualities that could lead to better recruiting and selecting of leaders are needed by the profession. Some respondents felt that technology education should target and recruit young professionals from all under-represented populations through provision of financial support, recognition at conferences, and elimination of insider groups.

Review of Literature

In preparation for writing this chapter, 13 sources on leadership were reviewed covering the time period from 1982 to 1993. Included in the review were the Council on Technology Teacher Education (CTTE) yearbooks, Dissertation Abstracts, monographs produced by technology educators, the *American Vocational Education Journal*, *Journal of Epsilon Pi Tau*, and *Journal of Industrial Teacher Education*. The 10 journals and magazines that were reviewed have provided (over the past 10 years) approximately 622 articles, of which 27 had leadership implications. A review of the 27 articles provided 16 that had merit for leadership development in technology education.

The 1982 to 1993 ACIATE/CTTE yearbooks were reviewed to determine if any leadership development knowledge and skills had been covered. Three yearbooks—those from 1983, 1986, and 1989—had varying amounts of information about leaders and leadership. The entire 1983 yearbook, *The Dynamics of Creative Leadership for Industrial Arts Education* (Wenig & Matthews), was devoted to leadership. In the 1986 yearbook entitled *Implementing Technology Education*, Lauda & McCrory identified a chronological list of selected leaders and the contributions they had made to technology education. The 1989 yearbook entitled *Technology Student Organizations* (Betts & Van Dyke) contained considerable information on leaders and leadership development.

Thirteen leadership articles were reported in ERIC. Eleven of the publications were in the *American Vocational Education Journal*. A majority of the leadership articles were written by Moss and Johansen (1991) from 1987–1991. Their 1991 publication identified and validated 37 leadership attributes. Finch, Gregson, and Fulkner (1991) published an article on "Approaches to Identification of Administrative Leadership." Finch, Gregson, and Reneau (1992) published *Vocational Education Leadership Development Resources: Selection and Application*. Both publications dealt with leadership resources and using task analysis to study leadership effectiveness. Murphy (1988, 1990) wrote two leadership articles that dealt with the factors that influence women in vocational education leadership positions. Westbrook's (1986) article identified the untapped leadership resource that could be found in minorities. Edmunds (1988) reported that, due to the mass of people entering vocational education without a background in the field, leadership has been made a priority by the American Vocational Education Association. Finally, Adams (1991), in a speech at the All Ohio Vocational Conference in Cleveland, Ohio, identified concepts, principles, and research that would influence modern leadership behaviors.

Technology educators provided 12 leadership articles. Of the 12 articles published between 1981 and 1990, the author wrote eight. Other articles were written by Oaks (1985), on using the state conferences to develop student leadership abilities; Hacker (1990), on applying leadership strategies to planning; Maley (1985), on leadership and professionalism; and Marshall and Householder (1987) on identifying the major responsibilities of future industrial education department heads.

LEADERSHIP PRINCIPLES AND THEIR FUTURE FOR TECHNOLOGY EDUCATION

Things We Have Learned About Leadership

A review of hundreds of studies and writings from experts (such as Bennis, 1989a, 1989b, & 1993; Bennis & Nanus, 1985; Burns, 1978; Drucker, 1993; Clark & Clark, (1994); The Forum Corporation, 1990; Gardner, 1990; Kouzes & Posner, 1987; Peters & Waterman, 1982, Waterman, 1987; and Ziglar, 1982), provide strong evidence for the need to identify the common principles, theories, or concepts of leadership. The literature points to the following:

1. Without leadership, organizations falter in times of change. Strong leaders see clearly and act decisively in times of turbulence. The only restraints are the quality of the neurological system and the drive to learn.

2. Leadership is critical from the board room to the shop floor. Success depends upon personal initiative and leadership skill throughout the organization.

3. Positions and titles bear little or no relationship to leadership performance. Leadership is linked to behavior, not position. Authority won't work, so leaders must earn respect to get followership. Leadership involves choice making, where followers and leader interact in a specified environment to accomplish a shared vision.

4. Leadership involves interdependence more than individualism. Leadership has more to do with building relationships than with being a lone ranger.

5. Leaders inspire others to take on the task of leadership. Sharing leadership with others produces greater productivity than the leaders holding all the power. Key terms are ownership and involvement of others for success.

6. Outstanding management skills are essential components of leadership. Strong management skills are required to maintain systems in response to rapid change. There must be a solid core or base from which innovation can be carried out.

7. Leadership is contextual. The leader must be well grounded about the environment, the people involved, the organizational structure, and how it is positioned to those who will use its services or goods.

8. Leadership can be learned. The Forum Corporation's view is that the learning process consists of three steps: (a) establishing the importance of leadership, (b) defining what it means to lead, and (c) helping people to be leaders.
9. Leadership is not style, it is action. "Popular mythology has always treated leadership as a matter of style. However, the roots of effective leadership are more practical . . . which are based upon a set of observed behaviors" (The Forum Corporation, 1990, p. 9).
10. Leadership has common behavior qualities that work successfully in varying settings. Research findings in business environments apply equally well in educational settings.
11. The best measure of a leader's performance comes from follower ratings. The least effective way to measure a leader's quality is by asking him/her.
12. Top leaders of today have leadership attributes similar to those of past leaders. They are (a) responsible for their actions; (b) hard driving; (c) persistent; (d) trustworthy; (e) constantly learning, even from failure; and (f) self-confident.
13. Leadership can be found almost anywhere, in the board room or in an informal meeting between two people. Leadership is not just for those in designated management positions, but for leaders and followers alike. At times, a subordinate assumes a leadership role and the designated leader becomes a follower. Many acts of leadership occur within small groups in obscure settings that involve people who hold neither power nor many resources.
14. Leadership is an aspect of power, yet a separate and vital process in and of itself.
15. Leadership is influencing others through knowledge, skills, economics, persuasion, institutional information, or empowerment to activate the motives and hopes of followers to achieve organizational goals.
16. What separates leaders from followers is that leaders are more skilled in elevating and nurturing followers' motives, then anticipating their responses for initiating and estimating appropriate positive power applications.
17. Considerate leadership behavior affects follower or subordinate satisfaction.

18. The essence of leaders' roles is persuasion: to motivate followers to join in an effort to accomplish valued goals and to persuade them that the goals are important.

19. Leaders' behavior aimed at structuring processes to be performed improves worker effectiveness.

20. Managers are not the same as leaders. Managers have the responsibility to see that things are done, while leaders build teams who share a common vision.

21. Stereotypes about being in charge interfere with communication between and among persons of different statuses.

22. No organization would be wise to select its leaders solely on the basis of observed personality traits.

23. When adequate leadership is absent for some reason, groups find substitutes.

Leadership Future for Technology Education

It has been mentioned that leadership is a process that must involve situations where a choice is possible (Jacobs & Jaques, 1990). The choice is based on resources, needs, and tasks to be completed. The leadership environment involves a leader and followers who are interested in finding solutions. Using this format, technology education has the opportunity to control its own destiny. The process requires anticipating and bringing about dynamic and positive change. This is the type of behavior that promotes uplifting interaction to create visions that inspire all to find meaning and hope in their work and lives.

How effective is technology education's leadership? Most survey respondents reported it to be average to good, while a few reported it to be low average (Wenig, 1993c). Anyone who has observed the profession may point to several bright spots. Generally, the rank and file technology educator feels leadership is important but not vital to the survival of the profession. Most agree that the International Technology Education Association provides the most influential leadership to the profession.

What about the Council on Technology Teacher Education's (CTTE) progress in the area of leadership? During the past 10 to 20 years, the council has gradually lost membership, power, and influence. In an interview, Kendall N. Starkweather, Executive Director of ITEA, suggested several reasons for this decline (Wenig, 1993, July). These included (a) closing of university programs, (b) staff reductions, (c) dropping student enrollment, (d) failure to restructure and change operational format over the years, and (e) electing officers whose professional positions are not teacher education. Which one or all of these factors might have influenced change is not the point of this discussion. What is important for CTTE is to seek continuously the type of leadership that establishes a clear and concise vision or direction for its future and then to execute a strategy for implementation.

Leaders in technology education are needed and they are needed in great numbers. Psychological studies have demonstrated real and important differences among people with predictive application to leadership performance. Technology education researchers interested in establishing measures of leadership capability should use the 17 technical steps as outlined by Clark and Clark (1994) in *Choosing to Lead.* Researchers using this process can identify those persons who possess leadership qualities. Even more important to the future of technology education is the demand for basic research on leaders and leadership. Unfortunately, most graduate students and their advisors have not considered or have not been interested in research related to leaders and leadership. Yet, strong leadership is the hope for the future of the technology education profession.

Leadership Development Models In Technology Education

How does a technology education person become a leader? There are several models or paths that technology educators might take to leadership positions. In the first model, technology education professional associations provide the most obvious and successful route for people seeking leadership positions (Wenig, 1992). The process starts by joining and getting actively involved in the local and state technology education professional associations. People volunteer for committee assignments, including serving as chairperson of one or more committees. If their work is of high quality, they move through the leadership positions that often result in being elected as the association's president. People who are active at the state level often become active in regional and national associations. Typically, these active members can become ITEA Regional Directors or affiliated Council representatives, which puts them on the ITEA Board of Directors. Once on the ITEA Board, their experiences allow them to become more confident and self-assured.

A second model to becoming a technology education leader involves pursuing a graduate degree. A technology educator can enter a graduate program and focus on a specific leadership development program. Typically, these people take leadership courses across campus. Gradually, with greater knowledge about leadership, they seek positions in which they may apply their knowledge to build experiential skills. These people enter the professional association pathway to leadership activities at a higher level than people described in the first model. If these people take an administrative position at the state level or in a college or university, the position allows them to sharpen their leadership skills to be on a fast track to enter the professional association arena.

In the third model, a technology educator sets out to become an expert in a specific area, such as curriculum research in one of the four technology systems. As these types of people study, present papers, research, and write, they become highly knowledgeable in a specific area. They have great influence if what they know has merit to those they seek to lead, and they have the ability to persuade skillfully.

A fourth model involves a process called pump priming where leadership development leads to increased professional involvement. Typically, those who have held leadership positions in the profession and its associations have been white males and, to a more limited extent, white females in recent years. Raising the consciousness of the profession has provided opportunities for minorities and women who want the opportunity and associated responsibility to achieve leadership positions.

Which model provides the fastest, least frustrating route and holds the most promise of success? When this question was asked of university faculty members, the response was that they would vote for president-elect candidates who have the greatest leadership experience. This writer, however, believes that people in the second model would provide the best leadership performance for the profession, since they have the knowledge and skills that technology education needs for future success.

Leadership and Change

The future of technology education relates directly to leadership for change. The theoretical base of leadership is founded on such words as innovation, entrepreneurship, restructuring, mission re-examination, visioning, assessing, listening, and curriculum reform. The most important route for a leader to travel in organizational change is grounded in the concept of cultural change. Sending an employee off for a one-week workshop on change and expecting big results when this person returns is wishful thinking. Once the workshop participant is back at work, this person's knowledge and skill usually fade and she/he returns to the same old routine. Drucker (1993) noted that change, to be effective, requires change in the entire organization's culture. All members of the organization must, therefore, be trained on site with strong support from the person in charge.

Leadership for change should always be a goal for technology education. Today's technology leadership is just as important for the teacher as it is for the administrator. Schools that succeed use the best on-site based leadership. The foundation of the best in leadership for any educational organization is thinking through its vision and mission, defining both, and establishing them clearly and visibly.

Visioning for Technology Education

Technology education lacks a potent and magnetic vision that grabs attention, that aligns, and that is so efficacious that everyone is lifted to a higher level of thought and performance. The survey respondents and the interviewees all agreed that the ITEA Professional Improvement Plan was the most significant process for moving the profession ahead. Now, a dominant, passionate, and shared vision must be the wave of the future for technology education.

Certainly, technological literacy is a most admirable goal for technology education. It fails, however, to be translated into a "slam dunk" that captures the emotions and imagination of the profession's members. Vision comes from a deep-seated passion. Perhaps the profession's mission could be to reach out to all, advancing technological literacy from elementary school through senior adults. The author envisions college and university courses attracting thousands who are sold on wanting to grow, prosper, and cope effectively in a highly technological, rapidly changing society. When action is hooked to dreams, it becomes a vision.

When leadership is morally purposeful, it becomes goal oriented. If the various associations and councils continue to operate as if the future is just like the present, they will face decline and eventually fail. Leadership that is successful deals effectively with change by using a vision as the cornerstone of progress, a merchant of hope. Baker (1992) identified the following four critical ingredients for visioning that seem to be appropriate for technology education.

1. Vision initially must be developed by the leader through intense listening and self-reflecting.

2. Vision is worthless unless shared to gain directed agreement. Members acting together provide power to the vision.

3. Vision must be comprehensive and detailed. It must provide the why, how, where, and what so each person can find a place in the vision for personal contribution.

4. Vision must be positive, inspiring, and big enough that it forces the group to stretch beyond normal to reach it. Value connection is gained through personal adaptation.

Furthermore, Baker added that the role of a vision is to determine personal or organizational destiny. The power word is empowerment, where leadership is pushed downward to the level where action is most appropriately applied.

Needed Research In Leadership

The future of leadership research in technology education is only a dream at this point in time. The review of the literature and dissertation abstracts in the profession indicated very little leadership knowledge production effort by the profession. The technology education profession is viewed by many educators as a stepchild to vocational education. They seek its value but wonder about its ability to lead in a crowded marketplace of other subjects. The power influence potential of leadership knowledge and skills for technology education is overwhelming, yet the future of its leadership seems minimal at best. The following research questions for technology education must, therefore, be addressed if the profession wants to realize its great potential fully.

1. What people power is the key to success for technology education? The evidence is markedly clear and without distortion. Human beings will give and give till it hurts if they are truly made to feel that they are worthy, appreciated, and valued.

2. What role should the profession play in realizing the leadership potential of under-represented populations?

3. Over the years, there have been philosophical differences about the mission purpose, goals, and objectives of technology education. How can technology education become consistent or trusted in what it believes to be philosophically paramount?

4. How can the profession and its associations collapse regional and/or geographical area differences? Regions of the United States (East Central, Midwest, Far West) have emphasized various traditional attachments to such areas as woods, metal, and drafting. Certainly, the

leadership must admit and agree to differences while providing a changed pathway to the truer nature of the more common reason for technology education.

5. What would be the benefits of ITEA or the profession providing leadership to empower the aging population of retired technology educators? As is true of society in general, educators are also graying in greater numbers. If CTTE and ITEA want to keep these people as active members, they also must be empowered through events and issues that interest them. They could conceivably become the most significant force of volunteers in the profession.

6. How can technology education associations attract and hold greater professional populations to their numbers? Elementary teachers, because of the diversity of their students' abilities and the need to improve basic skills regardless of potential, are now turning to manipulative activities. Historically, the technology education profession has served the elementary school teacher preparation student. Now we need to train technology education teachers in elementary school as well.

7. How can the Council on Technology Teacher Education (CTTE) apply the best in leadership to reinvent itself? Reinventing leadership strategies is a promising action for CTTE to regain and to enhance its image and influence. Incidentally, one of the most productive trends in management today, as reported in *Fortune,* is "reengineering." It's hot, it's happening, it's now, and it delivers, states Stewart (1993). Reengineering is not fine tooling something for improvement, but starting from the future and working backwards. The CTTE needs to establish a high profile ad hoc committee to research the process of reinventing or reengineering itself.

8. Why do most people in technology education reject the power and benefits of leadership development and growth? The International Technology Education Association (ITEA), as the most influential professional association in technology education, should reassert itself through leadership development action. The quality of future change in the profession is only possible with appropriate leadership knowledge and skill development. If leadership is mostly a learned behavior, then increasing leadership competence is needed to increase the performance of the association and to serve youth better.

9. What specific research questions should be studied?

  a. How does one lead in a volunteer position?

  b. What will be the leadership trends five years from now?

  c. How does one get so called leaders to act as leaders?

  d. How do we move from preparing leaders to bringing about actual change?

  e. Why is it so difficult for a good leader to be a good manager?

  f. How like or unlike is leadership in technology education to that of education in general?

  g. Why is it that few in technology teacher education value the significance of leadership knowledge and skill?

  h. What new and exciting leadership development models are needed by technology education to assure a more productive future?

  i. How can technology education increase the number and quality of leaders?

  j. Are there any transformational leaders in the profession and how did they become that way?

  k. What is the future need for leaders in technology education?

  l. How can a leader work best with a group to bring about and implement change?

  m. Where is the profession going with leadership?

The year 2000 is within sight. Young professionals ask, "Will the technology education profession even exist by the turn of the century?" It is said that there is no consistent direction or common set of beliefs. Recently, this author had his students survey the general public to ascertain their impressions of technology education. Repeatedly, the responses related to computers. This author strongly believes that the future of technology education lies in the hands of the leaders. As Burns (1978) was quoted as saying at the beginning of the chapter, the greatest leadership difficulty is intellectual. The quality of leadership starts first with knowledge that is based on sound and useful research.

SUMMARY

Armed with the knowledge and skill of leadership, technology education will survive and move to realizing its destiny. In this chapter the need, power, and purpose for leadership were discussed. Leadership at its best transforms the leader and the follower to higher and higher levels of mutual performance. Without the technology of leadership, an organization falls apart. Nothing ever is accomplished without direction, purpose, or a vision.

Research suggests that there are common qualities of leadership. These qualities, including determining a vision for the organization, are obtainable through training and development. The key tool to gain people power for the leader is empowerment. Empowerment means giving others the responsibility and resources to accomplish a given activity.

Leadership knowledge productivity by technology educators is very sparse. Survey respondents indicated that there is a need for more and better leaders, yet few people in the profession are interested in performing needed research and development activities. Evidence exists that the three ITEA Leadership Development Symposiums were a total success in producing leaders for local, state, regional, and national activities.

Normally, a technology education person becomes a leader in the profession through more and more involvement in professional associations. Unfortunately, this process is slow, limited, and still may not provide the type of leadership skills and knowledge that is required in today's rapidly changing society. The author urges members of the profession and its associations to become serious students of leadership knowledge and to comprehend its potential for charging effectively into the 21st Century.

As expressed at the beginning of this chapter, leadership at its best is making the right choice for all involved. We all have choices and we can choose to use information to become a better person, a better technology educator, and a better leader. The people of the profession, without qualification or reservation, hold the seeds of greatness for the future of technology education. Do we have the courage to step into tomorrow and choose success by studying and applying leadership knowledge and skills? Do we have any other choice?

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CHAPTER 17

The International Technology Education Association

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Associations move society forward, advance the goals of education, and act as a catalyst for change, while serving as a mechanism that allows people to further their ideas. No other institution in our society plays such a vital role as that of associations. The dynamics, leadership, and activities of a volunteer-oriented association, however, are seldom understood, even by those involved in its work and goals. An association represents the heart of the leadership of a profession. The International Technology Education Association (ITEA) serves as the heart of leadership for the technology education profession by helping it set direction and define values. The ITEA performs many leadership roles including, but not limited to, serving as a facilitator for change, a clearinghouse for information, and a perpetuator of ideas that professionals want enacted.

ASSOCIATION LEADERSHIP

The International Technology Education Association was created in 1939 as the American Industrial Arts Association (AIAA). Its creators were a group of individuals who were interested in furthering the educational principles being taught in industrial arts classes. These individuals saw a need to promote their field within the broad field of education, to create dialogue among their colleagues pertaining to quality teaching, and to work to advance practices by sharing ideas. They realized that working alone had its limitations and that there was a need to create gatherings or meetings that would serve as initiatives for others wishing to improve themselves and their field. As the profession evolved, the AIAA became the ITEA, but the activities and general reasons for the association's existence remained the same—to improve the field through the organized efforts of individuals working toward common goals. The ITEA and the technology education profession have been successful for over 50 years because of a democratic governance structure that was initially designed, then altered many times, to advance with the changes in the field and in society.

Effective associations attempt to create high performance over a long period of time. Their performance is measured in terms of their ability to assist members in their advancement of knowledge and in their participation in professional activities that will ultimately advance the level of practice in a field. The long-term success of an association depends upon its organizational system and its ability to provide opportunities to create change. The ITEA has created systems within the association that are used to strive for high performance. An example of one type of system is the Board of Directors. It is structured in such a way that the entire membership is represented as shown in Figure 17–1. A system of committees, task forces, and review boards operates within the structure to complete the work of the association. The general direction pursued by these groups is controlled by a strategic plan, which is created to cover multiple years and is reviewed on an annual basis. The constant infusion of new ideas, people, and tasks allows the ITEA to create change.

At the heart of leadership is a personal stand taken either by the association or by a number of members within the association. One example of a personal stand held by many technology teachers is the belief that individuals who have a working knowledge in applying technology in the solution of problems facing society will make stronger contributing members to that society. They will be more capable of making the world a better place in which to work and live. Personal stands like this one are incorporated into the personality or culture of the association and are articulated by the association through its members in the form of selected beliefs, values, and activities. Figure 17–2 is a statement entitled "This We Believe" and serves as an example of a personal stand articulated by the ITEA.

Personal stands and leadership directions of associations are always subject to change. When change does not occur, associations may become outdated because they do not advance with the times. For example, industrial arts was very appropriate in an industrial era when skills in woodworking and metalworking were the focus of subject matter being taught in the schools. Shop teachers found the AIAA to be appropriate for meeting their needs. As the world moved toward advanced uses of such technological advances as computer chips in a more sophisticated, fast-moving society, teachers found it necessary to make adjustments in their

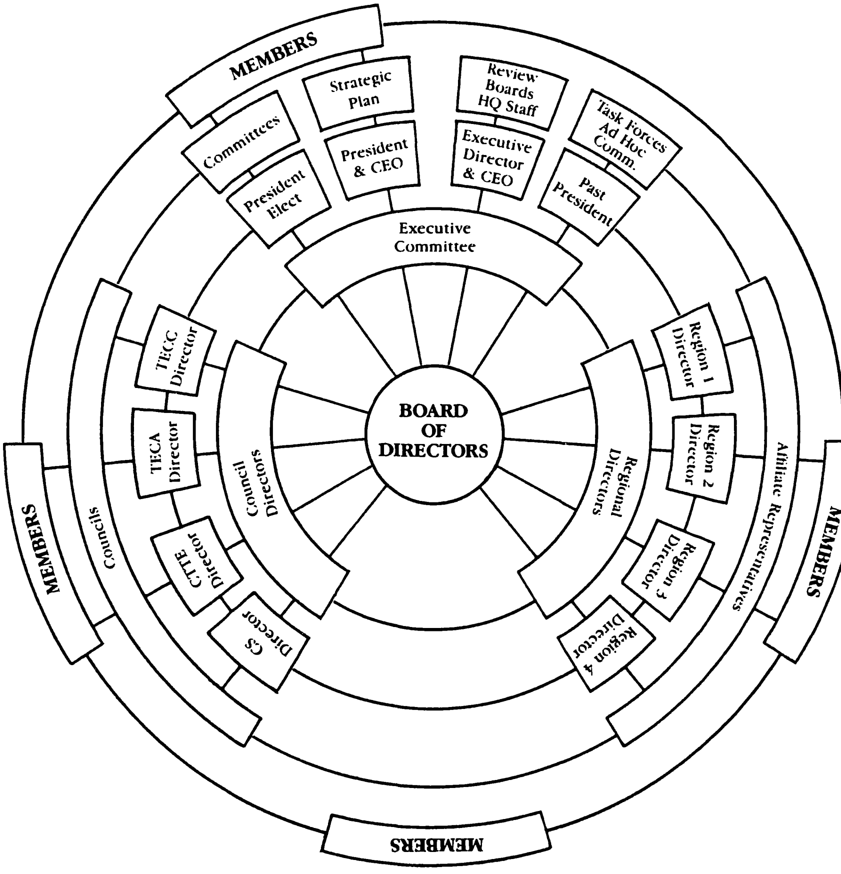

Figure 17-1: The organization structure of the ITEA.

thoughts, teaching styles, and the directions of the association that represented them. In addition, over the years the journal entitled *The Industrial Arts Teacher* became *Man/Society/Technology*, and then later it changed its name to *The Technology Teacher*. Various working groups within the ITEA changed the content of the journal from an industrial base to a technological base, as the name of the publication changed. One further result was an eventual name change for the association to the International Technology Education Association in 1985.

Association leadership evolves through listening to members' wants and needs, and then using a management structure that allows work to be accomplished in the direction that will assist the greatest number of members. If an association is to provide the leadership for its profession, it

The International Technology Education Association

This We Believe

Technology Education

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

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

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

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

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

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

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

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

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

Figure 17-2: The personal stand of the ITEA is articulated in This We Believe statement.

must complete two important steps: (a) directions must be set and values defined, and (b) cohesion must be created and energy mobilized. Both steps require considerable work, as it is not easy for a group of individuals to agree on directions. The presence of different values within a group sometimes makes it difficult to develop a cohesive strategy. The number of ways to achieve results seems to be endless. Associations, therefore, become complex organizations with many individuals attempting a variety of tasks, all at the same time. The ITEA has remained at the heart of leadership for the technology education profession by assisting in setting and defining values through the creation and dissemination of ideas such as the following:

- Jackson's Mill Industrial Arts Curriculum Symposium. This meeting of experts in the field resulted in a document and philosophical direction that furthered the programs of the 1960s and 1970s. Until the time of this symposium, there was no general agreement on future philosophical directions for the field.
- Standards for Technology Education. Standards for industrial arts were created as a result of funding from the United States Department of Education. The ITEA members worked to adjust the industrial art standards to make them applicable to technology education.
- Accreditation Agencies. The ITEA and its councils worked to coordinate all of the standards or criteria for technology education. The result was work that included interaction with agencies such as the National Council for the Accreditation of Teacher Education and the North Central Association.
- Philosophical Documents. The ITEA and the Technology Education Advisory Council (TEAC) have produced numerous documents that furthered thought and practice in the field. Publications such as *Technology Education: A Perspective on Implementation, Technology: A National Imperative, Technological Problem Solving, A Conceptual Framework for Technology Education*, and *Teaching Technology: A Teacher's Guide.*

These ITEA endeavors influence the way technology educators view their field and the types of learning activities they use in the classroom.

The complex nature of associations causes certain basic leadership functions to be characteristic of their work. Associations, for example, serve in leadership roles of influencing the way people think about reality. In the field of technology education, the ITEA plays a leadership role of influencing the way teachers think about other technology programs, the use of classroom materials and laboratory equipment, assessment trends, and standards in teacher preparation, to name just a few. One of the more recent roles played by the ITEA in influencing people's thinking has to do with changes in the content core for the field. Over the years, the field became known for its offerings in woods, metals, and drafting. As a result of major curriculum projects at universities in the 1960s, followed by societal changes with a technological orientation, the ITEA redirected content around systems areas. That content changed the subject areas of the field from woods, metals, drafting, etc., to manufacturing, construction, transportation, communication, and, in some cases, biotechnology. Future directions for the field are already being developed and tested. The result has been a total change in attitudes about instructional strategies, content, facilities, and assessment.

The ITEA has played a major role in participating in governmental relations and in influencing legislation. During the 1960s, for example, most legislation placed industrial arts under the vocational umbrella. As the field moved from industrial arts to technology education, the field's position within the vocational community also changed. Technology education is a part of the vocational community today, but not exclusively. In future years, in fact, vocational education could become a part of the technology community or body of content. The technology perspective of the association is now viewed by many people as being much broader, if not larger. Technology education is a subject area of its own and on the same level as mathematics, science, and English. Elementary school personnel are beginning to realize that there is a need to incorporate technology activities into their teaching plans.

ASSOCIATION CULTURE

An association's culture is based upon the beliefs and values held by its members and is defined by its actions on issues that are directed by its goals. These actions create perceptions in the public about the field, its members, and the work at hand. An association's culture rests upon its ability to create a sense of balance and to manage numerous functions simultaneously. The American Society of Association Executives (1993) identified the ways of thinking and the functions that make up the balance of an association's culture, as shown in Figure 17–3.

The International Technology Education Association's membership activities consist of the entire range of the thoughts and functions identified in Figure 17–3. Philosophical issues are articulated, ranging from the pragmatic to the idealistic. Member's and society's needs, when considered as a function of curriculum directions, are examined continuously. Leadership activities are prevalent in committee work. The individual's needs are combined with the association's needs to give dimension and direction to the field.

An association's sense of balance between functions is often a result of an image or reputation of which the main source of information is its members. Members desire to be respected by other members, the media,

Factors Affecting ITEA's Sense of Balance

Pragmatic ↔ Idealistic

Plan The Long Term ↔ Manage Short Term

Member's Needs ↔ Society's Needs

Analytical ↔ Intuitive

Mentor ↔ Mentored

Leader ↔ Participant

Principled ↔ Flexible

Career ↔ Home

Generalist ↔ Specialist

Personal Needs ↔ Association Needs

Figure 17-3: The ways of thinking and functions that comprise the balance of an association's culture as identified by the American Society of Association Executives.

government officials, and the public at large. They want to be socially responsible and recognized for their high integrity and ethical standards. Finally, members wish the association to be the spokesperson on behalf of the profession.

There are numerous values and qualities of an association's focus that are emphasized or de-emphasized according to the desires of the leadership. For example, some associations are considered to be visionary and of high intensity for their field. The ITEA's Professional Improvement Plans and strategic planning activities have created a vision for others to follow. The American Society of Association Executives (1993) identified several qualities that provide a perspective on the values that make up an association's culture. These qualities include being a visionary, exhibiting high intensity, demonstrating political astuteness, possessing high ethical standards, displaying a willingness to make tough decisions, possessing self-esteem, taking the initiative, being a risk taker, displaying common sense, having the willingness to be a lifelong learner, displaying a sense of humor, being a futurist, possessing an inquiring mind, and living a healthy lifestyle. An association's culture is a powerful factor to its existence. As the association adjusts to its evolving culture, it creates relationships with outside groups. The ITEA, for example, has developed strong working relationships with members of the scientific community including, but not limited to, the American Association for the Advancement of Science, the National Science Teachers Association, the American Society for Engineering Educators, and the National Council for Teachers of Mathematics. Other relationships have been forged with curricular groups, such as the Association for Supervision and Curriculum Development, Phi Delta Kappa, and the Council for Basic Education. Since administrators play a key role in the enhancement of technology education, ongoing relationships have been built with such groups as the National School Boards Association (NSBA), the National Association of Secondary School Principals (NASSP), the National Association of Elementary School Principals (NAESP), and the American Association for Secondary Administrators (AASA). In addition, the ITEA co-sponsors a conference with the NSBA, assists in providing technology exhibits with the NASSP, and provides educational materials about the field to numerous other professional associations. These working relationships allow the ITEA to share perspectives, assist in influencing policy beyond the field, and, in return, gain important input from other associations.

Professional societies and public and private foundations also play an important role in an association's culture. The ITEA interacts with organizations such as the American Chemical Society, the Edison Electric Institute, the Society of Manufacturing Engineers, the Society for Automotive Engineers, and the National Council for Manufacturing Sciences. Numerous foundations have been partners with the ITEA over the years including such groups as Chevron, Ford, Autodesk, and the Technical Foundation of America. The ITEA's relationship with the Technical Foundation of America has been of significant value to the profession, since they have co-produced numerous mini-conferences, speaker programs, the enhancement of standards, special issue symposiums, and have provided support in the formation of advisory groups. Relationships with other groups have provided scholarships or grants to enhance specific programs.

The ITEA also has extensive relationships with its state and province affiliates and with other national technology education associations. The most important outgrowth of these relationships has been the exchange of information and the promotion of similar initiatives related to teaching and learning. The ITEA has affiliates in almost all of the states and provinces in North America and has selected associations in countries such as Australia. Affiliates in North America are assigned to one of four regions: Eastern, East Central, West Central, and Western. Relationships are maintained with other national and international associations that are not formally affiliated with the ITEA. Included in this group are the Design and Technology Association, with headquarters in the United Kingdom;

the Pupils Attitudes Towards Technology, with headquarters in The Netherlands; the Australian Council for Education in Technology; the Portugal Technology Education Association; and the Greece Technology Education Association, to name just a few.

The ITEA also serves as a model for its affiliate and sister associations. Affiliate associations are defined as those technology education groups that are from states, provinces, and countries and that have formally completed paper work to participate in the ITEA's governance activities. Affiliate members are eligible to participate in the meetings of the House of Delegates, Teacher and Program Excellence Awards programs, and in countless other awards, grants, and scholarships. The affiliated associations share their efforts in such work as that pertaining to communications, membership services, governmental relations, and professional development. The ITEA honors outstanding affiliates for their efforts in these areas.

There are many times when modeling is exemplified in leadership such as when the ITEA's membership services, pamphlets, or promotional materials are emulated by its affiliates. In addition, the ITEA may gain from the work completed by its affiliates, as it did when it created school program excellence winners, a program initially developed by the New York affiliate. The ITEA's planning format and strategies have also been emulated, as have selected other formalized procedures. These formal and informal modeling processes work to the betterment of all parties.

The ITEA's sister associations consist of other national and international associations, the purpose of which is to improve education and to share common characteristics. Many of the ITEA's organizational structures, membership campaigns, slogans, and thrusts have been adopted by sister groups. For example, the Council for Exceptional Children has used the ITEA's procedures for its work with the election process. Conversely, the ITEA has patterned its Distinguished Technology Educator (DTE) program after the American Society of Association Executives program for Certified Association Executives. The DTE program provides a means for recognizing outstanding performance and accomplishment in the field of technology education. Consideration for the award is based upon documented evidence of leadership and management skills, continuing participation in association education programs, and demonstration of leadership in association, community, and personal activities. It is a recognition that takes into account solid practices in teaching, research, service, and association work at the local, state or provincial, national, and international levels.

The interaction with affiliate and sister associations has allowed the ITEA to move the profession and its programs forward, while concurrently assisting other educational groups. Interrelationships exist in governance structures where the affiliate sends delegates to national and international meetings, excellence award recipients at the state and provincial level are recognized at the next level, and a sharing of information for publications all produce a better dissemination of information. Learning from the experiences of affiliates and sister associations is a fundamental benefit of close relationships. Finally, over 50 teacher-oriented educational associations have worked together to create better insurance programs for their associations' members through a trust (Trust for Insuring Educators). This trust is a vital program for many of the ITEA members.

Associations create major markets for suppliers who provide numerous services for members in the field. Trade shows, therefore, usually play an important role in the life of an association and its members. Relationships that are developed between associations and suppliers are to the mutual benefit of all in terms of income generated, availability of support materials, and educational access to the latest developments available in the profession.

The fabric of an association's culture is related to a balance that exists among strategies, values and qualities, desired images or reputations, and relationships that create opportunities. The culture is adjusted as the personal stand of the membership and leadership evolves and changes. In addition, as society changes, its needs and desires create a different profile or culture for the association. The ITEA's culture has transformed significantly over the years. It began as one of the vocational subject areas, but during the 1980s and 1990s it became more involved in the math, science, and technology interrelationships while maintaining some vocational influence. The ITEA's culture will continue to change many times in the years ahead as its leaders use their philosophies and experiences to direct the work of the association.

The values and qualities of the ITEA and the technology field will also change significantly, and they must if the field is to survive. Standards or benchmarks set by the profession, for example, will create changes in content and methodology used in the classroom and laboratory. Furthermore, these alterations will influence the type of programs offered at seminars and conferences. Advancing technology will also create different thoughts and practices in the field. These changes are typical of those that will create a different culture for the ITEA, as a culture must stay in tune with the latest occurrences in education and society.

POSITIONING THE ASSOCIATION

Associations must have a vision before they can create actions that will benefit their members. Missions and visions are very focused on goals so as to attract the attention and commitment of others. They have high values, exhibit strong positions, and are well developed. They address what others feel or want and create a willingness to take risks to achieve the desired outcome. A vision is articulated as a result of a well-thought-out mission and/or vision statement. Mission and vision statements are usually short, exacting, and give a feeling of forward movement. For example, the American Society of Association Executives' vision in 1993 was "to be a worldwide leader and catalyst in inspiring the association executives and their organization to build and renew society" (p. 1). Their mission, in relation to their vision, was to promote "excellence in association management and works to increase the effectiveness of associations worldwide to better serve members and society" (p. 1). The ITEA's mission statement for the time period of 1993–1995 is to "advance technological literacy" (International Technology Education Association, 1993a, p. 1). This statement is followed by five goals that deal with the field's philosophical foundation, teaching and learning systems, research agenda, and the increase in the quality and number of technology teachers. Figure 17–4 contains a listing of the ITEA's goals in its professional improvement and strategic plans covering the time periods 1983–1986, 1986–1990, 1990–1995, and 1993–1995. The ITEA's strategic directions are pursued through these plans and result in a coordinated catalyst for action by its members. Its subdivisions are further organized into tasks to be completed by committees, task forces, or other individuals working to make reality out of an initial dream or thought. Each task is placed in a time line for completion.

The success of ITEA's mission or vision is felt when its members are working to implement its ideals. When individuals are involved in purposeful activities, they are contributing to the profession and the association. They are performing their role in moving the profession forward. The members' role changes often by using the structure of the ITEA as a mechanism for implementing their thoughts and ideas. One example of the ITEA's membership formulating change occurred during the 1980s, when it started using Professional Improvement Plans (PIP) to create a direction for the field. Prior to this time, planning had been a year-to-year activity. A strategic plan was developed for the years 1983–86 to provide longer, more consistent action that would provide greater influence on activities of the profession.

The initial impetus for using a PIP came about as a result of input from the National Industrial Arts Advisory Council (NIAAC). The NIAAC was created by the AIAA to gain, from corporate people, advice that could be used by the association and profession. One of the outcomes of the original council meetings was a realization of the need for better planning and focus of the profession. This caused the president of the association, Ronald L. Foy of Texas, to suspend all other activities and use the board members in creating a PIP, also called a strategic plan.

1983–86

- Interpret the evolution and relationships of society, industry, and technical means.
- Establish beliefs and values based on the impact of technology and how it alters environments.
- Develop attitudes and abilities in the proper use of tools, techniques, and resources of technical and industrial systems.
- Develop creative solutions to present and future societal problems, using technical means.
- Explore and develop human potentials related to responsible work, leisure, and citizenship roles in a technological society.

1986–90

- Develop and improve model technology education programs.
- Expand support for people to develop a technological literacy.
- Upgrade teacher education.
- Research and develop new/improved instructional delivery systems.
- Expand curriculum resources.
- Enhance the expertise of personnel.
- Improve public awareness and support.
- Involve business and industry.
- Increase personal commitment to the profession.
- Strengthen the Foundation for Technology Education.

1990–95

- Develop and refine a philosophical foundation and curriculum framework that addresses technological literacy.
- Publish materials and activities to enhance teaching and learning styles.
- Complete research activities to advance technological literacy.
- Establish technology education as the primary discipline for advancing technological literacy.
- Enhance the number and quality of technology educators.
- Advance the teaching of technological literacy.

1993–95

- Position technology as a basic area of academic study.
- Provide leadership in developing curriculum.
- Support teachers in implementing their programs.
- Enhance participation of minorities and women in technology.

Figure 17-4: Goals of ITEA's strategic plans.

The basic nature of the 1983–1986 plan was to address the technological nature of what later became the technological field. Nothing in the plan at that time, however, called for a change in name of the journal or the association. Input for these changes was gathered through a member survey and, acting in response to the survey, name changes were acted upon by the Board of Directors. In the case of the name change of the association, a change in the constitution was necessary. The process by which the name change came about demonstrates how members can have an impact on their field through their association. Once the name change occurred with the ITEA, the affiliates went through a similar process. Most of the affiliates in the United States and Canada today have changed the name of their associations. Teachers are considered technology teachers, not shop teachers. This change in terminology was a spin-off from the original Professional Improvement Plan. Association activities changed the entire direction of a field in less than five years, opened up new opportunities for its members, and addressed the positioning of the field in conjunction with society.

The technological culture of the association and the philosophical direction of the field allowed better interaction with the National Aeronautical and Space Administration, the United States Department of Energy, the American Association for the Advancement of Science, the National Science Foundation, as well as many other groups. These relationships led to greater participation by the ITEA in such activities as serving as reviewers for projects being considered by the above mentioned groups, receiving funding from these new sources, creating various standards and benchmarks that included technology education, and communicating with groups interested in promoting technology education. Each activity created a stronger position for the field when a significant amount of educational reform was occurring in the United States.

Not all changes in the positioning of an association occur as a result of major strategic directions, in fact, most changes occur in small incremental steps. For example, one member may write a monograph that supports a particular view while another member may encourage the use of a new electronic networking system. There are no limits to the creativity that a member can bring to an association. Normally, the only limitation is in resources, both human and material, that hinder immediate progress.

MAJOR FUNCTIONS OF ASSOCIATIONS

The International Technology Education Association delivers services to its members in four major areas: professional development, governmental relations, membership, and communications. Services in each of these areas are developed as a result of volunteer and headquarters staff activities. The primary function that causes people to become interested in an association is directly related to their interest and desire to stay current in their chosen profession. Doctors, lawyers, architects, educators, and many other types of professionals realize they must continue their own professional development in order to be successful. Associations respond to their needs by providing the types of services required by their members.

Many technology educators view the professional development role of their associations in terms of annual conferences. At these conferences, there is a combination of themes that provide opportunities to listen to keynote speakers, interact with colleagues, attend and participate in interest sessions, view exhibits at the trade show, and collect resources of various types that hopefully will result in a motivation for self-improvement. Presentation topics, for example, may focus on many different subjects including safety, teacher training, technology transfer, environment, equity initiatives, accreditation, etc. Some of the educational experiences one may gain include participation in poster sessions, leadership sessions, teacher/program awards, and governance meetings, as well as observing student competitions. The ITEA has also sponsored numerous mini-conferences and workshops (separate from the annual conference) over the years, on subjects including standards implementation, technology awareness for elementary teachers, the classroom of the future, leadership in technology, computers in technology, critical issues in technology, and model programs in technology education.

Individuals who believe that membership in an association is just a chance to attend a trade show or receive a journal are shortsighted in their expectations of what an association can do for them. Associations are the arena where interaction can take place with fellow professionals for personal and professional growth. Individuals who join for shortsighted reasons, however, are generally disappointed in their membership over the long run because they have not engaged in many of the activities of the organization. They have not participated in directing their association's activities, they have not given time in order to receive new knowledge, they have looked for major results without being truly involved, and they have never experienced associations functioning for their own good.

Professional development takes on many meanings within an association. For example, changing technology has caused the use of telecommunication networks with which professionals create much of their own professional development through electronic interaction. These networks are a part of the association's activities as they provide information and share important details through this system. Publications and journals also provide a different form of professional development. The ITEA publications such as

The Technology Teacher and the *Journal of Technology Education* provide members with new ideas, directions, and examples of the latest developments that are shared for professional enhancement. In addition, The Technology Bank provides hundreds of short articles and copies of presentations within the categories of organization and management, projects and activities, curriculum and programs, speeches and proceedings, international papers, and videos. Print and non-print media are at the root of professional development and advancement.

The ITEA's involvement in professional development has allowed leaders in the profession to create new standards and outcomes, explore teaching strategies and philosophical directions, promote enthusiastic new leadership, and provide opportunities that enhance the network of colleagues pursuing excellence in technology teaching. Professional development is more than an event or publication. It consists of a continuing involvement in one's chosen profession in order that one may grow and share in new knowledge.

The field of technology education has an abundance of opportunities to further one's professional development. Within the last few years, for example, the ITEA has delivered the world's largest technology education conference and trade show, created critical issues documents and concept papers, supported an electronic network for its members, and served as a forum for sharing information with technology educators throughout the world. Professional development means creating access to knowledge that allows technology educators to conceptualize new techniques, knowledge, and practices that can be shared with their fellow members.

An association's relationship with the public outside of its immediate profession is one of the greatest potentials for service to its members. That service is often provided through some type of governmental relations program that the association conducts to keep decision makers informed, to stay coordinated with sister organizations, and to provide leadership to affiliates who must pursue similar efforts at their level. The direction of a governmental relations program spawns out of the overall vision and goals for the association. For example, past leaders in the field focused on vocational legislation for funding which resulted in industrial arts and technology education being identified in vocational legislation. This has met with varying degrees of success at the affiliate level, depending upon ability to affect support.

The ITEA is now focusing its efforts to position technology education into legislation that will make technology education a new basic in education such as its counterparts in math and science. The ITEA's legislative efforts take on many forms, the majority of which are conducted through small meetings with key decision makers. Efforts may even include work as part of a team of other associations with similar interests. This work is ongoing and consists of a never ending process to influence others in the worth and need for technology education in the schools. For example, lawmakers may introduce legislation that was drafted specifically to address the technology community. This type of effort was seen in the model programs legislation that was funded during the early 1990s. At other times, the addition of phrases in existing legislation provides the support needed for technology teaching.

The ITEA also works as a clearinghouse for information to share with its affiliates. When affiliates have success in mandating technology studies in their localities, the process they followed and information they learned are shared with other ITEA affiliates. For example, when technology education was mandated in the state educational systems of New York (during the 1980s) and Maryland (during the 1990s), this information was shared with other state affiliates. When Florida received significant funding for its educational programs, this information was also shared with affiliates. The key is to provide a constant source of information and direction to decision makers so that they can create support for the field.

Members of an association expect their organization to be the voice that expounds upon the virtues of the field. They expect constant interaction with sister associations, governmental agencies, and other groups who might be able to assist in furthering their cause. The ITEA is involved in all of the above activities in order to create and improve support for teachers and institutions in the field. The most effective governmental relations program depends upon educational efforts to keep all the public informed, create opportunities through coalitions, and play a role as a catalyst for positive reform. The ITEA has been and continues to be a member of numerous coalitions for the good of its members.

An individual's or a group's membership in an association is its formal relationship to being an active partner in progressing the work of the field. The level of involvement is determined by the interests and desires of those involved. The significance of the progress is dependent upon the visions provided, services desired, and organizational structure. The ITEA's membership structure provides services by assisting members in fulfilling their needs, both large and small. Membership services provide information, share differing viewpoints, develop selected skills, translate initiatives, and deliver benefits specific to the technology teacher. One of the major perceived benefits of being an ITEA member is the communication of information through publications, conferences, seminars, workshops, and other means that keep the members fully informed. Information is the key to increased members' knowledge and the ITEA performs that creating and disseminating role for technology teachers.

A growing profession is one with varying opinions and directions to be pursued. These directions are often management oriented, philosophical in nature, and politically important to the future of the field. The ITEA is the conduit for sharing ideas while serving as the trial ground for implementation. Verbal and written forums are provided to test members' perceptions of what should be attempted and pursued. During any given year, the ITEA will conduct programs that provide technical skill updates, governmental relations training, and leadership training for its members. At the same time, schools are offered programs such as the ITEA's Elementary School Membership, with services to schools in recognition (Elementary Program Excellence Awards). Scholarships for teachers, teacher and activity strategies, and grants for the improvement of programs are also available. The Elementary Program Excellence Awards are designed to recognize, from each state and province, one outstanding elementary school that excels in its implementation of technology education. The recognition ceremony takes place at the ITEA's annual international conference during a general session program. Grants are also given to elementary schools that are seeking assistance with the implementation of technology activities. In addition to educational institutions, corporations become members of the ITEA to take advantage of exhibitor and advertiser opportunities. They track events in technology education and remain close to the profession's leaders.

Progressive educators create initiatives that are communicated through forums or through a working structure that allows them to be accepted, rejected, or modified. Initiatives are often modified as they are advanced within the structure, which is a part of the process of acceptance and change. Professional presentations and media form the most common means of testing ideas, although many would argue that the most informative discussions take place during informal settings at professional meetings. The ideas are then translated into meaningful initiatives through media or other types of communication systems. One example of translating initiatives relates to the philosophical growth of the field. The many curriculum research projects of the 1960s were analyzed at the AIAA meetings and conferences. The *Standards for Industrial Arts* document was created in the late 1970s, followed by the efforts of a group of leaders who created a document entitled the *Jackson's Mill Industrial Arts Curriculum Theory* (Synder & Hales, n.d.). This document was used to modify the standards when the ITEA underwent the transition from industrial arts to technology education in the mid 1980s. This modification caused the *Standards for Technology Education* to be written. These new standards were used to produce the basic direction for the National Council for the Accreditation of Teacher Education criteria, which were later approved for the accreditation of college and university teacher education programs. More recently, these initiatives were used as a basis for a symposium to further the initial work of the Jackson's Mill symposium participants. The document created from the symposium participants' efforts was entitled *A Conceptual Framework for Technology Education* (1990).

Associations are also able to create programs that present special benefits for their members, and ITEA is no different from other associations in this regard. Services include various types of insurance and annuity programs and travel savings. These types of benefits are not necessarily the main reason that individuals or groups join an association, although they may become side benefits that are useful to the members.

Communication is the single most important aspect to the successful functioning of an association. The ITEA's communications system serves two specific purposes: (a) external communications to the public and to other professional groups, and (b) internal communications for keeping the membership in touch with the latest developments in the field. Various forms of media and methods used in this communication process can range from an international telecommunications network to individually written or spoken messages. The majority of the external communications are addressed to members of governmental agencies, who are apprised of the latest developments in technology education. These communications may be to elected officials or to professionals in agencies who have work in common with the goals of technology education. Other contacts are made with administrators and groups in education, such as elementary and secondary school principals, school boards, and curriculum developers, including those in the math, science, and engineering associations. This work is never ending and becomes extremely important because the partnerships that are formed seem to strengthen all people who are involved in the process.

There are numerous communication systems within the ITEA network. The policy and procedures outlined by the ITEA Board of Directors are communicated to all committees, task forces, House of Delegates, and the entire membership. These communications are two-way, in that the work of the various groups is reported back to the board through liaisons. Members are invited to share their thoughts by direct correspondence to their elected board members. The communications system empowers every member with the ability to be heard and provides direction as a result of their thoughts.

The major functions of an association can be described in many ways. The preceding paragraphs have briefly outlined the many functions of the ITEA through professional development, governmental relations, membership, and communications. It is through these functions that ITEA serves the profession by furthering technology education.

ASSOCIATION SUBGROUPS

Any discussion of an association would be incomplete without mention of the subgroups that make up the organization. They are known as interest groups, and they allow members who have specific commonalities to interact with their colleagues. Subgroups within the International Technology Education Association are committees, task forces, councils, and sections. Each is unique in purpose and advances the overall goals of the association and each provides an avenue of involvement for members who are part of its operation. Their role in the work of the association can be of great importance.

Every association has committees whose members are normally appointed by the elected governing group, commonly known as the Board of Directors. The ITEA uses committees to gain grass roots input from its members and to conduct a large portion of its business. All members may submit their names for consideration as committee or task force members. The committees are classified as standing or operating and include categories such as affiliation, awards, conference, contests and special events, curriculum, elections, international relations, membership, public relations, professional development, research, resolutions, and standards. A standing committee is ongoing, in that it has a set of functions that are repeated each year. For example, the affiliation committee is charged with keeping all of the ITEA's state and provincial associations' communications current. This includes assisting with the annual House of Delegates meeting and other activities that may pertain to delegates or the membership. An operating committee also has set tasks, but is frequently charged with new tasks related to the nature of its work. For example, the research committee may work on enhancing graduate research, while at another time it may work on enhancing elementary education. Committees have had such tasks as preserving the history of the association and profession, providing recognition for members who merit awards for exceptional work, directing conference and professional development activities, insuring the election of officers, and handling the governance of the association (such as through the House of Delegates). Committees have also been used to help in determining directions for the association. For example, committees have assisted in creating directions for research, governmental relations, public relations, and standards. These efforts have national and sometimes international ramifications that affect the entire profession as well as other educational disciplines. The charge to the committees is directed by the mission and goals of the association. One example of such direction can be seen in the work of the ITEA's curriculum committee, which is provided philosophical guidance by the Board of Directors, who ultimately establish policy and direction for the association. Research efforts and standards creation are then coordinated with the curriculum direction. The result is a group of coordinated committees involved in the work of the profession.

The ITEA task forces operate very similarly to committees, with the major difference being a charge to complete an assignment during a given time period. When that charge is completed, the task force is disbanded. Task force initiatives are often directed at getting a new idea started or building a major direction that needs to be addressed by the association. For example, the task force dealing with the relationship between liberal arts and technology education conducted surveys of the profession to identify experts within the field. They created a document to further thought in this area and considered steps to become an ongoing section within the association. While the task force work has been completed, the original ideas are still growing in a different form within the structure of the association. It is at this point that task force work is often administered into the work of the association through existing committees or the creation of a new committee.

Councils have been created within the ITEA as shown in Figure 17–1, according to positions held by professionals in the field. (See Chapter 18 for a more complete description of the ITEA councils.) Past councils have consisted of professionals who have been interested in teacher education, supervision, elementary education, college and university students, and association officers. Councils can be created or dissolved according to the needs of an association. The ITEA's council dealing with association officers, for example, was dissolved at the beginning of the 1990s, after functioning for many years. Many of the activities of this council were then assumed by the association in its normal functions. An example of a new council in the future could be composed of professionals from community colleges.

Each council operates in a manner similar to a mini-association, with its own set of missions, goals, officers, governance structure, committees, etc., that contribute to the overall strengths of the ITEA and the profession. A representative of each council serves on the ITEA's Board of Directors. The councils provide leadership, such as with the Council on Technology Teacher Education, which adjusts and directs standards for the college and university level technology education programs. An endless number of leadership tasks are completed by the councils' activities and provide the nucleus for the overall direction of the association.

Sections within an association are created to allow its members to develop an alliance with a professional, philosophical, or technical direction that is common to their daily work or interest. Sections are new to the ITEA and have come about as a result of a bylaws change that allowed for their creation during the 1990s. In the future, sections in the association may include areas such as design, engineering, liberal arts, communications, manufacturing, biotechnology, and transportation. Sections are created as a result of individuals forming a focus group to complete work in a given area. If a preset minimum number of individuals are interested, the Board of Directors takes action to create a section. If interest wanes after years of existence, the section could be disbanded by the Board. The ITEA sections have officers who will direct action in completing work that simultaneously promotes their interest and advances the association. Sections, however, do not have a seat on the ITEA Board of Directors.

ADVISORY COUNCIL AND FOUNDATION

Two groups have a special relationship to the work of the ITEA and technology education. They are the Technology Education Advisory Council (TEAC) and the Foundation for Technology Education (FTE). Their work is closely synchronized with that of the ITEA to provide a partnership for progress. The TEAC was formed by the AIAA in the late 1970s to provide information to the technology education profession about current developments and possible trends in technology and industry, and their implications for technology education. The council's activities are advisory, as it has no official policy-making authority. Topics of discussion are determined by the chairperson as a result of input from council members, the ITEA Board of Directors, and members of the technology teaching profession. Its primary purpose to date has been to provide input to the profession by advising the Board of Directors on issues brought before it. The specific purposes of the TEAC are as follow:

- Recommend ways of resolving discrepancies between the programs and philosophies of technology education and current industrial and technological practices.
- Recommend content direction to improve the relevancy of technology education.
- Suggest methods of improving the public's perception and understanding of technology education.
- Assist in the cooperation between industry and education to improve the educational process.

Advisory council members are selected from corporations, government agencies, special interest groups, general education groups, and the field of technology education. Council members have been frequent presenters at the ITEA conferences, have provided assistance with testimony before the United States Congress, and have written documents that have furthered the work of the profession. The TEAC has played a key role in setting the direction of the profession during the growth period of the 1980s and 1990s. This council has served as a major source for the ITEA and the profession to gain advice beyond their normal working environment.

The Foundation for Technology Education was created by the ITEA to work on projects that would have long-term significance for the profession. Although it is a separate entity from the ITEA, its purpose is to create programs and to work in conjunction with the ITEA in order to enhance the field of technology education further. The foundation has provided scholarships to technology education professionals, furthered research efforts that would help the field to progress, and built a financial base in order to increase services and work for technology educators. The mission of the FTE is to provide supporting programs to the ITEA, while assuring that our schools prepare students to think and act from a technological perspective. The foundation has sought to provide support that will accomplish the following:

- Enhance the knowledge and skills of technology teachers and attract capable people into the teaching profession.
- Promote collaborations between schools and various other sectors of the community in order to enrich educational resources and support school improvement.
- Enhance effective learning about technology in schools.

The financial base of the foundation was created by members who desired to build the FTE endowment. The FTE's financial stability is ongoing through multiple-phase campaigns. Phase I consists of pledges and contributions from current and past officers of the ITEA (initiated in 1987). Phase II consists of pledges and contributions from the ITEA members and business representatives who serve the technology education profession (initiated in 1989). Phase III consists of pledges, grants, and donations from corporations and organizations supporting technology education (initiated in 1992). Initial corporate pledges are recognized as Partners for Excellence in Teaching Technology. During the 1992–1993 year, Phase III began with a campaign to generate an endowment for awarding scholarships annually, beginning in 1993. The scholarship program is designed to achieve the following purposes: (a) attract capable people into technology teacher preparation programs, and (b) provide incentives to current technology teachers in order that they may strengthen their knowledge base and skills in technology. In March 1993, a campaign was initiated within the FTE to raise at least $30,000 to endow a Donald Maley Memorial Scholarship. Once this endowment is established, an annual scholarship will be made available to master's and doctoral degree students or classroom teachers who are pursuing action-based research in areas such as activity-based learning or integrated curriculum development.

SUMMARY

The International Technology Education Association is the major change agent for technology education today. It is an organization of members who join together to advance their common interests in technology teaching. The association is able to accomplish what no one member could achieve individually. In doing so, a public service is provided that advances education, strengthens nations, and provides positive leadership to people. The strength of the ITEA is limited only by the imagination and determination of its members. The position in society held by technology education now and in the future will be directly affected by how well the ITEA can mobilize its members, hone its leadership and political skills, and become the voice on issues that will contribute to strengthen the profession.

The ITEA's structure is deliberately designed to provide members with leadership opportunities and a forum to exercise their talents. It serves as a contributor to the direction that the discipline desires to pursue. The ITEA's strength is reflected in the nature of the technology teaching profession. The ITEA and the profession at large will be strong if the ITEA's organizational leadership recognize issues, address challenges, and take advantage of opportunities that result in making them a positive force in education reform.

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CHAPTER 18

Professional Councils and Associations

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For almost half a century, specialized national groups have supported professionals in the study of technology and industry. These groups were initiated at a time when the field was referred to as industrial arts and they have continued into the era now known as technology education. The groups have attended to issues surrounding technology education in order to improve K-12 programs as well as teacher education programs. While these groups have not individually or collectively exercised control over the field, they have made phenomenal contributions to strengthen individual programs and technology education as a whole. As a result, classroom teachers, teacher educators, program supervisors, and students have been the beneficiaries of all these efforts.

Four councils and two student associations that have made a significant impact on the technology education profession will be discussed in this chapter. In addition, a newly formed council, the World Council of Associations for Technology Education (WOCATE), will be presented, since its work will most assuredly impact the technology education profession. The councils and associations are profiled in Figure 18–1.

RELATIONSHIP TO THE INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

Chapter 17 of this yearbook details the impact of the International Technology Education Association (ITEA) on the technology education

NAME	PREVIOUS NAME	AFFILIATED WITH ITEA	MEMBERSHIP March 1994
Council of Technology Education Associations (CTEA)	American Council of Industrial Arts State Association Officers (ACIASAO)	Yes	*
Council on Technology Teacher Education (CTTE)	American Council on Industrial Arts Teacher Education (ACIATE)	Yes	837
ITEA-Council of Supervisors (ITEA-CS)	American Council of Industrial Arts Supervisors (ACIAS)	Yes	70
Technology Education for Children Council (TECC)	American Council for Elementary School Industrial Arts (ACESIA)	Yes	147
Technology Education Collegiate Association (TECA)	American Industrial Arts College Student Association (AIACSA)	Yes	565 members 47 chapters
Technology Student Association (TSA)	American Industrial Arts Student Association (AIASA)	No	82,739
World Council of Associations for Technology Education (WOCATE)	**	No	***

* Dissolved 1993
** New association as of July 1993
*** Soliciting members as of July 1993

Figure 18-1: Profile of councils and associations within the technology education profession.

profession. It is important that the reader understand the ITEA's relationship with the councils and associations through its affiliation process. Groups affiliate with others to formalize a working relationship to achieve similar goals. Recent developments in the structure of the ITEA warrant consideration, since they have had a definite impact on the councils and associations connected with the ITEA. All of the councils and one of the student associations have been affiliated with ITEA for many years, and this relationship was maintained in the 1993 revision of the ITEA by-laws.

Changes in the by-laws altered the structure of the ITEA committees, as well as those in the Council of Technology Education Associations (CTEA), Council on Technology Teacher Education (CTTE), International Technology Education Association-Council of Supervisors (ITEA-CS), Technology Education for Children Council (TECC), and Technology Education Collegiate Association (TECA). The Technology Student Association (TSA) was not affected, since it is not an affiliate of the ITEA. Prior to the by-laws revision, even though affiliated with the ITEA, councils and associations maintained committees independent of the ITEA. The 1993 revision of the constitution (ITEA, 1993) established a Committee on Committees made up of the ITEA past-president and an appointee from each council to oversee joint ITEA/Council committees and their work. The newly established joint committees are the Conference, Contests and Special Events, Government Relations, International Relations, Liaison, Public Relations, Resolutions, Standards, and Student Organizations.

The relationship between the ITEA and the affiliated councils and associations was enhanced through the development of long-range plans. These plans are designed to lead the profession into the next century. In 1983, the ITEA established its first long-range plan, called the Professional Improvement Plan (PIP). (The association had previously utilized an annual program of work.) The total effort involved in the development of the PIP influenced each council and association to generate its own long-range plan. Initially, these plans were developed with each council and association retaining its own autonomy. With the restructuring of the ITEA's committee structure, the councils and associations retained their autonomy, but there was extensive coordination among the ITEA and the councils and associations. The coordination was further enhanced by having the past president of each council and TECA serve on the ITEA Board of Directors.

The reader should not minimize these actions, since they represent the first time in the history of the profession that the ITEA and the councils and associations formalized collaboration through long-range planning and the committee structure. While each council and association would retain its own identity and have its own governance structure, the long-range plans and the new committee structure instantly provided coordination of activities, thereby avoiding duplication and increasing the talent pool to handle identified activities. More importantly, this coordinated effort placed the technology education profession in a very strong position by establishing a greater sense of unity among its professional groups. These two acts, the development of long-range plans and the changes in committee structure, represent highly significant actions taken in recent years by the technology education profession.

The annual conference of the ITEA is a time when all councils and associations can hold meetings and provide workshops, forums, and special interest sessions for their members. At the 1994 conference in Kansas City, Missouri, for example, sessions were held covering such topics as accreditation, ethics, CAD, early childhood, cross-cultural education, recruitment and retention, performance assessment, construction, manufacturing, communications, and manufacturing. These sessions are typical of those conducted each year at the annual ITEA conference. The TSA also holds an annual conference, which is attended by students and chapter advisors. This conference is separate from the ITEA conference and is usually held in June of each year.

COUNCILS OF THE TECHNOLOGY EDUCATION PROFESSION

The councils of the profession have existed for many decades, with the first one being formed in 1950. The contributions of each council have been significant, with each contribution strengthening the profession through the efforts of countless individuals who volunteer many hours of work for the good of the councils. The reader is encouraged to review Chapter 16 (Ray, 1979) of the 28th yearbook of the American Council of Industrial Arts Teacher Education entitled, *Industrial Arts Education: Retrospect, Prospect.* It traces the contributions of each council from their formation to 1979. This chapter will focus more on recent developments, with emphasis placed on directions being pursued, anticipated future directions, and influence on policy making within the profession at large.

Council of Technology Education Associations

Initial interest in forming a council for industrial arts state association officers began in 1954, with an organizational meeting occurring one year later. A constitution was adopted on April 24, 1956, and the council became known as the American Council of Industrial Arts State Association Officers (ACIASAO). It was designed to assist affiliate member organization officers to lead their local groups. In 1986, the council adopted the name of the Council of Technology Education Associations (CTEA).

Council activities centered on helping the leadership of local groups at the state level. To facilitate these activities, the council annually distributed three newsletters and prepared a directory of association officers. Another annual event was participation in the ITEA conference, where special interest sessions dealt with such topics as organizational management, newsletter publication, and public relations. In addition, the council presented annually an "Association of the Year" award.

The CTEA was dissolved in 1991, based on a vote of the council membership. Dissolution stemmed from three primary factors: (a) duplication of efforts with those of ITEA regional representatives, (b) financial considerations, and (c) low membership. The latter reason, low membership, would have been a critical factor had the council not been dissolved, since the revised by-laws of ITEA (1993) mandated that affiliated councils maintain 100 or more members.

Council on Technology Teacher Education

The Council on Technology Teacher Education (CTTE) has been in existence since 1950, when it became the first council to affiliate with the American Industrial Arts Association (AIAA). Until 1986, it was known as the American Council on Industrial Arts Teacher Education (ACIATE). The change in name was implemented to reflect the changing philosophy within the field from industrial arts to the study of technology.

Purposes of the Council . The constitution and by-laws of the council (Council on Technology Teacher Education, 1993) list the following three purposes for its existence:

Section 1. To support and further the professional ideals of Technology Education.

Section 2. To define and strive to achieve the purposes and professional goals of technology teacher education, and to enlist the greatest number of people in this endeavor.

Section 3. To stimulate research and the dissemination of information of professional interest. (p. 1)

Mission and Goals of the Council. The mission of the council is to improve, advance, and develop a standard for judging the contemporary nature and level of attainments of technology teacher education (Council on Technology Teacher Education, 1990). The *1990–95 Professional Improvement Plan* (Council on Technology Teacher Education, 1990) identifies eight goals. These goals are the following:

1. Provide input to and support for the goals of the ITEA and work with the ITEA, other ITEA councils, and other associations to promote technology education.
2. Identify highly capable individuals who are interested in technology education programs, and to recruit qualified individuals to become teachers of technology education.
3. Promote appropriate professional development activities for technology teacher educators.
4. Assume a leadership responsibility (a) to identify and operationalize the components and criteria for quality technology teacher education programs and (b) for the development of appropriate criteria for evaluating and accrediting programs of technology teacher education.
5. Develop and promote an awareness of and support for implementing quality undergraduate and graduate teacher preparation programs in Technology Education.
6. Encourage and support research and scholarly activity in all aspects of technology teacher education that will result in advancing the profession.
7. Promote the dissemination of relevant research findings, successful curriculum innovations, and the best of scholarly thought in technology teacher education.
8. Develop an international working relationship with other countries for studying the issues related to the promotion of technology education. (pp. 1–2)

Major Accomplishments. The CTTE has a history rich in tradition and productivity. Throughout its existence it has maintained a large membership, with over 1,000 members, many of whom have contributed significantly to the literature of the field. Among its primary accomplishments in recent years have been a change in name, establishment of accreditation standards, and publication of a yearbook series, as well as monographs.

The change in name from the American Council on Industrial Arts Teacher Education to the Council on Technology Teacher Education (CTTE) represented a change in philosophy, that is, a move from industrial arts to a study of technology. The CTTE was clearly a leader in this movement within the profession and remains so today. At the same time, the CTTE focused its attention primarily on teacher education, whereas in the past it had spent considerable time assisting classroom education, particularly grades 7–12. This change allowed the council to be more productive in helping teacher education, since that had been its stated mission since 1950.

In 1986, the CTTE engaged in a project with the ITEA and the National Council for the Accreditation of Teacher Education (NCATE) to develop technology education accreditation standards at the undergraduate level. It must be emphasized that, from the very beginning, the intent was to generate accreditation standards for technology education, rather than for industrial arts. These standards were approved by NCATE in April 1987 and were implemented immediately. The technology education program at Ball State University in Muncie, Indiana was the first to receive full accreditation by NCATE and by March 1994, 32 institutions had received full accreditation or accreditation with stipulation.

Since this was the first time programs in technology education had the opportunity to be accredited, the ITEA and CTTE had to take action to prepare individuals (folio reviewers) to analyze materials submitted by institutions seeking accreditation. These reviewers were trained in workshops presented by the council and could render a decision including one of the following: accreditation, accreditation with stipulation, or denial. In addition, two types of workshops were delivered for the membership. Both were extremely beneficial to the profession, as demonstrated by the improvements made in teacher education programs around the United States. The two types of workshops were the following: (a) those intended to assist institutions applying for their initial accreditation, and (b) those designed to assist institutions in revitalizing their teacher education programs to represent the contemporary practices in the profession. The latter type of workshop was designed to assist institutions prior to their application for initial accreditation. Continuing accreditation requires institutions to file annual reports, have data reports reviewed by the Unit Accreditation Board every three years, and host an on-site Board of Examiners team every five years (Council on Technology Teacher Education, Accreditation Committee, 1992). As a result, the CTTE developed another type of workshop to help institutions continue accreditation following the initial accreditation. The new standards presented a unique challenge for those institutions that needed to under go a transition from industrial arts to technology education. While some institutions initially resisted accreditation, it became a new reality and made a monumental change in the transition process.

The publication of an annual yearbook since 1952 has been one of the most significant contributions of the CTTE to the technology education profession. The yearbook series has been well received within and outside of the CTTE membership, with many yearbooks used as textbooks in teacher education programs. In 1986, when the council was changing from ACIATE to CTTE, a conscious decision was made to provide yearbooks directed at helping teacher education programs transition to the study of technology. Yearbooks were written to cover the primary content organizers advocated in the *Jackson's Mill Industrial Arts Curriculum Theory* document (Hales & Snyder, n.d.), e.g., communications, transportation, manufacturing, and construction. The yearbooks developed since 1952 are presented in the introductory material of this yearbook.

The CTTE has maintained a rich tradition of providing monographs to assist teacher educators. Three monographs were published in recent years to assist teacher educators in developing undergraduate and graduate programs and learning environments: (a) *Elements and Structure for a Model Undergraduate Technology Teacher Education Program* (Monograph 11) by Richard M. Henak (1991) of Ball State University; (b) *The Essential Elements of a Quality Graduate Technology Education Program* (Monograph 12) by John R. Wright (1991) of Central Connecticut State University; and (c) *Planning Technology Teacher Education Learning Environments* (Monograph 13) by Douglas L. Polette (1991) of Montana State University.

Influence on Policy Making. The CTTE has functioned as one of the primary councils of the profession throughout its history. Its high level of productivity (e.g., publications and workshops) has allowed the council to maintain a large membership and to generate discretionary funds to support its many professional activities. The council has had a major influence on the ITEA, the other councils, and the technology education profession as a whole. Its publications are used nationally and internationally within and outside of the technology education profession and are consistently referenced in research studies. The publications remain a primary source of information for teacher education programs.

The CTTE has taken an active role in seeking federal funding for technology education. Members have been involved in writing proposals as well as in lobbying key legislators in Washington, D.C. One individual deserves to be mentioned in this regard for his significant and lifetime contributions to the profession. This individual is Donald Maley, who invested a great deal of time in support of the profession during his tenure as Professor and Chair at the University of Maryland and, following his retirement from the university, assisted the profession in influencing legislation in Washington, D.C. Federal funding for the study of technology in the future will certainly be due in a large measure to the influence of Professor Maley.

When the ITEA and the CTTE engaged in accrediting programs through NCATE, the latter allowed a member of CTTE to serve on NCATE's national boards. Membership on these boards has given recognition to technology education and has increased the awareness of technology education among the other disciplines. The CTTE has been especially influential with NCATE in two areas: (a) It has been able to influence policy decisions concerning accreditation of specialty areas, that is, the accreditation of specific disciplines; and (b) it has allowed technology education teacher educators to serve as on-site reviewers for unit accreditation of universities.

Anticipated Future Directions. The *1990–1995 Professional Improvement Plan* of the CTTE (1990) lists 36 long range goals. While this list is very impressive and achievable, only 10 of the goals will be identified for purposes of this chapter. These goals are the following:

1. Develop NCATE standards for the graduate level technology teacher education.

2. Be a strong advocate for encouraging and providing support for technology teacher education programs to become NCATE accredited.

3. Provide publications that will address critical professional issues, identify different but effective curriculum models and illustrate diverse exemplary undergraduate and graduate teacher education programs.

4. Develop a system for improving communication between CTTE and ITEA, its councils, and other associations interested in Teacher Education.

5. Work with the ITEA, its councils, and other professional associations to encourage legislation which will provide broad-based technology education programs.
6. Work with professional associations from other countries to promote technology education and provide the opportunities for and disseminate of how other countries are addressing major issues in technology teacher education.
7. Identify practices that have been successful in encouraging professionalism among technology teacher educators.
8. Develop the support for and implement a national campaign to recruit technology teacher educators.
9. Stimulate and disseminate research and scholarly activities that will advance quality technology teacher education.
10. Encourage and provide support for leadership development in the technology teacher education profession. (pp. 2–3)

ITEA-Council of Supervisors

The American Council of Industrial Arts Supervisors (ACIAS) has been in existence since 1951, at which time it became the second council to affiliate with the American Industrial Arts Association (AIAA). In 1987 it became known as the International Technology Education Association-Council of Supervisors (ITEA-CS), following the trend that had been established with the name change of the American Industrial Arts Association to the International Technology Education Association (ITEA).

Mission and Purposes of the Council. The mission of the council is to motivate and provide support for supervisors of technology education programs. The constitution and by-laws of the ITEA-CS (1990) list the following four purposes:

1. To support and further technology education.
2. To promote effective supervision and program development at local, regional and national levels.
3. To provide a vehicle for exchanging ideas, programs and legislation related to the goals of technology education.
4. To provide for the personal and professional growth of the Council's members. (p. 1)

Major Accomplishments. The ITEA-CS has provided significant contributions to the profession by assisting personnel who have responsibility for directing technology education programs in the elementary and secondary schools. Among the council's many accomplishments in recent years were conference programs, awards, publications, a newsletter, and increased involvement of females and minorities.

The ITEA-CS has consistently provided excellent programs at the ITEA annual conference, which comprise the primary activity of the council. These programs are designed specifically to assist members in their role as supervisors of programs at the local, state, and regional levels. The activities of ITEA-CS were expanded to include supervisors from other countries. Conference objectives are the following:

1. To provide an opportunity for state and local supervisors in technology education to meet.
2. To provide a forum for the exchange of information concerning technology education.
3. To present relevant information for state and local supervisors that will assist them in their responsibilities.
4. To exchange information and suggestions from those interested in improving technology education.
5. To provide an opportunity to recognize outstanding contributions from peers.
6. To expose leaders of business, labor, and education to the benefits of technology education.
7. To provide an opportunity to learn more about the cultural and technology resources available internationally. (International Technology Education Association-Council of Supervisors, 1992, p. 3)

Five major awards are presented by the council annually, in the categories of Supervisor of the Year, Outstanding State Supervisor, Outstanding Local Supervisor, Distinguished Service Award, and the Presidential Citation Award. The council produces an excellent newsletter entitled *Superlink* three times per year for its members. This publication provides information concerning council activities and implementation strategies for the improvement of technology education. Recognizing the need for females and minorities in the ranks of the supervisors, the council has placed a high priority on the recruitment of these two population groups. This goal is being achieved with considerable success.

Influence on Policy Making. The ITEA-CS has been one of the most active councils in influencing policy making. Among its primary contributions, the following need to be cited: (a) influencing the American Vocational Association to change the name of its Industrial Arts Division to Technology Education, (b) requesting the American Vocational Association to work with the ITEA on the Carl Perkins reauthorization, and (c) initiating the development of a publication entitled *Technology Education Facility Planning Guide*. The council has provided strong leadership in developing, implementing, and evaluating innovations in school programs. This influence has made a marked difference in programs at the local, state, and regional levels.

Anticipated Future Directions. The council plans to continue providing leadership in the improvement of programs through its workshops, publications, and interaction with the ITEA and its respective councils. Greater emphasis will be placed on increasing membership, with a high priority on international interaction. In addition, the council will seek to integrate its activities to a greater extent through the reorganized structure within the ITEA.

Technology Education for Children Council

The Technology Education for Children Council (TECC) has been in existence since 1962 but until 1986, it was known as the American Council for Elementary School Industrial Arts (ACESIA). The change in name followed a trend that had been established with the name change of the American Industrial Arts Association to the International Technology Education Association.

Goals and Purposes of the Council. The council has established the following three goals:

1. To increase membership of TECC at all levels including early childhood, elementary, secondary, and university.
2. To provide leadership to ITEA relative to matters concerning elementary technology education.
3. To identify and complete tasks that eventually will provide a substantial increase in the use of technology education units and activities in

elementary classrooms. (Technology Education for Children Council, *Professional Improvement Plan*, n.d., pp. 1–4)

The constitution and by-laws of the TECC (1989) list four purposes of the council. These purposes are the following:

Section 1. To define, stimulate, coordinate and strive for the ideal form of technology education as a vital aspect of education in the elementary school.
Section 2. To enlist and coordinate the efforts of all people contributing to the development of this program.
Section 3. To publish materials of use and information to the profession, with special reference to technology activities in elementary grades.
Section 4. To perform any necessary acts in upholding these purposes, including the receiving, holding, and administering of funds and property. (p. 1)

Major Accomplishments. The TECC serves as the primary advocate for elementary school technology education in the United States, a role that is now progressing internationally. Some of its primary accomplishments in recent years were in the areas of positioning, international representation, workshops, monographs, yearbook contributions, research, grants, and awards. The council has raised awareness of elementary technology education, thereby meeting its primary thrust. This awareness has occurred among its members and, perhaps most importantly, within local educational agencies.

In 1992 the council placed an international representative on its executive board. Jan Raat from The Netherlands was selected for this position. This effort deserves attention for two reasons: (a) It recognized the need for international representation through a proactive stance, and (b) it was the first time an international representative outside of North America was appointed to any council or board within the technology education profession.

The council has designed and offered excellent workshops for teachers and administrators. Some of these workshops have been offered at the annual ITEA conference, while others have been offered on-site in school settings. The workshops have been designed to provide a rationale for technology education, along with strategies for implementation at the elementary level.

The TECC has developed 16 monographs since its inception, providing a rich resource of literature. Monographs completed since 1983 are the following:

- Doyle, M. A., & Ceprano, M. A. (1985). *Reading-technology connection in the elementary curriculum.* (Monograph 12).
- Russell, R. (1985). *Architecture: Building my world.* (Monograph 13).
- Llot, J. F. D., & Llot, H. G. (1988). *Language development in the elementary school technology context.* (Monograph 14).
- Doyle, M. A., & Calder, C. R. (Eds.). (1989). *Technology education for the elementary school.* (Monograph 15).
- (1993). *Classroom activities.* (Monograph 16).

Robert G. Thrower and Robert D. Weber (1974) of Trenton State College provided a seminal piece of work with the 23rd ACIATE yearbook entitled *Industrial Arts for the Elementary School.* In addition to this yearbook, two important chapters were added to more recently published yearbooks. These were "Industrial Arts And Its Contributions To The Education Of The Elementary School Child" (Williams, 1982) and "Elementary School Technology Education Programs" (Peterson, 1986).

Two recent dissertations have been completed on the topic of elementary technology education. These are the following:

- Brusic, S. (1991). *Determining effects on fifth grade students' achievement and curiosity when a technology education activity is integrated with a unit in science.* Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg.
- Dunlap, D. D. (1990). *Comparing attitudes toward technology of third and fourth grade students in Virginia relative to their exposure to technology.* Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg.

Beginning in 1993, the ITEA, in concert with the TECC, provided grants for the advancement of technology education in the elementary schools. Two grants of $250 were offered at the Charlotte, North Carolina conference to Terry Thode at the Hemingway School in Ketchum, Idaho and Cindy

Etchison at the Dranesville Elementary School in Herndon, Virginia. The TECC also recognizes individuals for exemplary work through two awards. These are the Educational Leadership Award and the Distinguished Service Award.

Influence on Policy Making. The council has not directly influenced policies in a formal sense at either the national or international levels. It has, however, made great strides in involving school districts in elementary technology education. Workshops conducted at the ITEA conference and at the state and local levels have generated a great deal of interest on the part of teachers and administrators. As a result, many new programs have been implemented and existing programs have been improved.

Anticipated Future Directions.. The TECC has great potential for expanding its membership, due to the large number of elementary schools and the increasing interest in technology education. In line with this goal is the recruitment of individuals who are experts in developing and implementing technology education and who are willing to share their expertise. The multiplier effect of such action has great potential for the discipline and for children throughout the world.

The need for research in technology education in the elementary schools remains a priority for the future. The identification of content and instructional strategies, as well as the use of interdisciplinary approaches, is of paramount importance. Teachers in the schools have been in dire need of instructional materials for the elementary age child. Dissemination of useful materials is, therefore, a high priority.

STUDENT ASSOCIATIONS OF THE TECHNOLOGY EDUCATION PROFESSION

Fortunately for the technology education profession, two student associations (Technology Education Collegiate Association and Technology Student Association) are in place and functioning with a great deal of energy and success. These two associations allow students to have the opportunity to become involved at all levels, elementary through teacher education. The reader is encouraged to examine the 1989 CTTE yearbook entitled *Technology Student Organizations* (Betts & Van Dyke, 1989), which provided the profession with the first and most complete definitive work on technology student organizations. This yearbook is an excellent reference in that it describes why student organizations are an important part of the curriculum, what exists in the technology education profession, and how student associations can be utilized to enhance the curriculum.

Technology Education Collegiate Association

A collegiate organization to promote the technology teaching profession has been in existence since 1972. Originally known as the American Industrial Arts College Student Association (AIACSA), the group temporarily lost ITEA Board representation in the early 1980s. The group was reorganized in 1986 as the Technology Education Collegiate Association (TECA). The change in name followed a trend that had been established with the name change of the American Industrial Arts Association (AIAA) to the International Technology Education Association (ITEA). The TECA is a sponsored program of the ITEA and is administered by an administrative advisor appointed by the TECA Management Board. This structure provides the association with a representative on the Board of Directors of the ITEA (Robb, 1989).

Approximately 40 to 45 colleges/universities affiliate with the TECA annually. Only affiliated chapters are allowed to participate in chapter contests, and annual chapter and individual awards. Each affiliated chapter is permitted one vote on student (officer) elections, constitutional changes, and other TECA activities at the national level.

Mission and Purposes of the Association. The mission of the TECA is to involve and motivate future technology teachers in professional and leadership development activities related to the profession (Technology Education Collegiate Association, 1987b). As members of the association, TECA students should do the following:

1. Acquire experiences and resources needed to become effective technology teachers.
2. Exchange ideas and activities within and outside the profession to foster a positive, consistent image of the technology education profession.
3. Benefit from student membership in the International Technology Education Association and professional development activities. (p. 1)

The constitution of the association lists three general purposes. These are presented in Article 1—Name, Governing Authority, and Purposes of the Constitution (Technology Education Collegiate Association, 1987a) as the following:

> Section 3. The purpose of TECA is to promote leadership, fellowship, scholarship, and a philosophical foundation for future technology teachers, through college chapter coordinated activities at the campus, state, regional, and national level.
>
> Section 4. TECA shall serve as a pre-professional organization providing opportunities to develop the professional attitudes of future technology educators through active participation in ITEA/TECA proceedings.
>
> Section 5. TECA shall provide an open line of communication between chapters for exchange of ideas related to technology education and the purposes of college student associations. (p. 1)

Major Accomplishments. The TECA is the sole national association representing technology education students in teacher education programs. Robb (1989) listed four primary chapter activities advocated by the national office. These activities are to involve students in technology-based experiences, to enhance local club fund-raising tasks, to provide community service, and to participate in professional programs.

There have been three major accomplishments of TECA during the past few years. These accomplishments may be categorized as becoming a student-run association, engaging in technology-based activities, and conducting conferences.

The TECA deserves a great deal of credit for functioning as a student-run association. While advisors assist at the chapter level and there is a management board and an administrative advisor, students handle the majority of the work. This characteristic typifies the ability of the association to build the leadership for the future of the profession, thereby meeting the association's mission.

Technology-based activities require students to become aware of and participate in technological developments and processes. These activities take place at the local chapter level as well as at regional conferences and at the ITEA annual conference. Competitive events, field trips, and guest speakers are included among the events in which they participate. These activities strengthen a chapter's ties to each member's major area of study.

Multiple regional meetings are conducted for the TECA affiliated chapters. Currently, this involves an early fall meeting in the mid-west and a late fall western regional conference in Denver, Colorado. An eastern regional meeting is usually held in Virginia Beach, Virginia each spring. Attendance at these conferences is excellent and is increasing each year. In addition to the regional meetings, the TECA is well represented at the annual ITEA conference. During each conference students participate in professional sessions plus competitive events.

Influence on Policy Making. The TECA, as a student-run association, is not structured to influence policy making at the national level. It must be noted, however, that the TECA works well with the ITEA and, with representation on the Board of Directors of the ITEA, the TECA can influence the ITEA's policy decisions. There is also a liaison with the Technology Student Association, with the intent of generating a progression from TSA membership into TECA and on to the teaching profession.

Anticipated Future Directions. The TECA utilizes an annual operational plan to direct its activities. The yearly plan includes a description of all activities, publications, competitive events, and the agenda of professional meetings. Primary among TECA's activities are the following: (a) organizing and conducting an introductory meeting with new international officers, (b) organizing and conducting regional conferences and continuing activities at the annual ITEA conference; and (c) continuing publication of its two communication devices—*TECA Talk* and *College Comment*.

One additional direction for the future deserves to be mentioned within this chapter. This is the role the TECA has performed in recruiting and retaining future technology education teachers. There is an increasing need for new teachers and the TECA can function as a tremendous motivating device. In 1993, the association had 45 affiliated chapters from a pool of 55 institutions. The potential within these teacher education programs is phenomenal and must be enhanced by the profession.

Technology Student Association

The Technology Student Association (TSA) is a legal entity of the Technology Student Association, Inc. which is a non-profit educational corporation. It consists of those persons who are officially designated by the states to serve as state supervisors of technology education and is organized to serve as the sponsoring agency for TSA (Technology Student Association, 1988b, p. 1). The TSA has been in existence since approximately the 1967–68 school year, but until June 1988 it was known as the American Industrial Arts Student Association (AIASA). The change in name followed the trend that had been established with the name change of the American Industrial Arts Association (AIAA) to the International Technology Education Association (ITEA).

Mission and Purposes of the Association. The mission of TSA is to promote leadership and personal growth in a technological society (Technology Student Association, 1988a). The constitution and by-laws of the association list four general purposes. These are presented in Article II—Purposes of the Constitution as the following:

1. To assist State Associations in the growth and development of TSA.
2. To assist State Associations in the development of leadership and citizenship in social, economic, scholastic and civic activities.
3. To increase the knowledge and understanding of our industrial technological society.
4. To assist technology education/industrial arts students in the making of informed and meaningful occupational choices. (Technology Student Association, 1992, p. 1)

Goals of the Association. The TSA has identified four goals to provide direction for the association in the future. These goals are the following:

1. Students will be provided opportunities to enhance their participation in and contribute to a technological society.
2. Teachers will obtain services which help to deliver instruction and manage activities to ensure that students become technically literate and proficient in a democratic society.
3. Affiliated associations will be provided resources and services empowering their administration and management of viable local chapters.
4. A corporate office will be sustained to manage Association fiscal affairs and coordinate the mission of the Technology Student Association. (Technology Student Association, 1988b, p. 1)

Major Accomplishments. The TSA represents the sole national association representing technology education students at the elementary, middle, and secondary schools. Through its chapters and state associations, TSA has had a major influence in advancing the study of technology for students and chapter advisors. The intense interest among the chapters and their members can be seen in the annual conferences of TSA, which consistently attract approximately 2,500 students. Among its primary accomplishments in recent years have been the following:

1. The TSA has, through strong leadership at all levels, positioned itself as a dynamic force within the school system. Its growth in the past five years is evident in its membership and in the quality of its programs.
2. The TSA changed its name to reflect changes that were occurring in the profession, to reflect changes in the ITEA, and perhaps most importantly, to reflect a new focus through its programs. This focus brought changes in its mission, competitive events, format of its annual conference, and materials designed for use in schools.
3. In recent years there has been a quantum jump in the membership of the TSA, moving from 43,000 members in 1987–88 to over 82,000 in 1994. A goal of 100,000 members was set for 1993–94 which will represent, when achieved, an increase in the membership of over 50,000 in 10 years. With this critical mass, the TSA increased its financial base, allowing it to expand its services to the membership.
4. The TSA Honor Society was implemented to identify students who deserve special recognition for their efforts in academic studies, strong leadership abilities, and participation in activities in support of their school and community. This effort motivates members to gain personal recognition as well as recognition for their school's TSA chapter. In addition to being recognized at the annual TSA conference, inductees' names are sent to various scholarship foundations and college referral organizations.
5. TechnoKids was developed in 1992 as an interdisciplinary technology program for grades K-6. This program was designed to enhance the integration of technology education into all areas of learning and to teach critical thinking and problem-solving skills, while promoting collaborative learning. The year 1993 was used for pilot testing the

program and on August 1, 1993, TechnoKids was implemented on a national basis.

6. The TSA National Advisory Council was founded in 1991. This council consists of 36 representatives from business, industry, education, and government who lend their expertise to meet the goals of the TSA. The council is divided into four committees: career exploration, conference development, council expansion, and corporate development.

Influence on Policy Making. The TSA has placed its priority on redirecting its efforts to meet the needs of its chapters and their students. The association does not have a formal lobbying effort, but is working with appropriate legislative bodies to position itself as a leader among student organizations. The opportunity for strong political action on behalf of all entities involved in technology education is essential for future progress. The TSA welcomes the opportunity to work with the ITEA and its councils to meet the needs of students at all levels.

Anticipated Future Directions. The TSA has established a goal of having at least 2,000 local and international chapters by 1994, with at least 100,000 members. It is possible that the TSA could be one of the largest youth/student organizations in the country, comparable in size to 4-H. With children as young as five years old as members, membership will increase and will be enhanced through strong retention programs. In addition, as the definition of technology education is expanded, more students will become eligible for membership.

With increased membership comes greater visibility within schools and communities. The association has an inherent public relations component, since working with youth in a highly professional atmosphere garners attention from the media. As a result, national visibility will be heightened measurably with international visibility an inevitable consequence.

The TSA has begun efforts to secure support from corporations and foundations. As American business/industry strive to become more competitive, the TSA presents a unique option within the schools, thereby increasing the chances for financial support. As TSA members join the ranks of business, industry, and education, the TSA will receive attention that is much more pronounced. It is also likely that the association will receive federal funding in the future, due to its high visibility, productivity, and potential.

The TSA has a very positive track record and is gaining momentum. It will rapidly gain positive recognition at all levels of the education profession as a result of having positioned itself as a positive force within the United States school system. It will be seen as an association that provides excellent programs for students, acts as a feeder for teacher education programs, and is equivalent in stature to any other student group in the country.

The TSA currently has less than 10 international chapters. The potential for serving students in other countries is recognized, however, and formal contacts have been made in a number of countries. The future holds great promise for extending the potential of the TSA internationally and a great deal of progress is anticipated in the coming years.

WORLD COUNCIL OF ASSOCIATIONS FOR TECHNOLOGY EDUCATION

In April 1992, the International Conference on Technology Education was held at Weimar, in Thuringen, Germany. This conference was attended by representatives from 17 national associations and organizations for technology education. The ITEA was represented by 10 of its members, a number of whom presented papers.

It was at this conference that the charter members generated a set of guiding principles to implement the World Council of Associations for Technology Education (WOCATE). The founding executive committee consisted of Kevin Morgan, Chair (Australia); Michael Dyrenfurth, Vice-Chair (United States); Gordon Warren, Treasurer (England); and Dietrich Blandow, Secretary (Germany). It was at a subsequent meeting held in Paris, France from July 1–3, 1993 that a constitution was formally ratified, thereby making WOCATE a new association within the arena of the technology education profession.

Mission and Goals of the Council. The WOCATE constitution states that the mission is "to promote technological literacy for all people by facilitating communication and cooperation among the world's associations dedicated to the development of Technology Education in ways consistent with the promotion of greater understanding between the peoples of the world" (World Council of Associations for Technology Education, 1993, p. 1). Membership is available to associations with a demonstrated commitment to the delivery, preparation of people for delivery, or management of technology education. Three classes of membership are available: full, associate, and affiliate. Membership is also open to individuals.

The World Council of Associations for Technology Education (1993) serves to focus its efforts internationally in the following areas:

1. Enhancement of the quality of Technology Education.
2. Recognition of the diverse and lifelong nature of Technology Education and the importance of the complex interactions between technological, social and natural environments.
3. Establishment of Technology Education as a priority area of learning, for all persons, throughout all education and society.
4. Promotion of research into Technology Education.
5. Recognition of Technology Education as a significant component in the development of viable and competitive economies through the development of human resources.
6. Clarification of the interface between Technology Education and other disciplines.
7. The study and understanding of the role and responsible utilization of technology in the improvement of the quality of life and the human character of the working world.
8. The promotion of technologies that are environment friendly and that lead to sustainable development.
9. Establishing networks and facilitating communication between and among technology educators and significant professional and lay groups.
10. Strengthening existing member associations and promoting the development of needed associations.
11. Liasing [sic] with key international agencies.
12. Pursuing such other activities appropriate to further the mission of the association. (pp. 1–2)

Influence on Policy Making. At the time of the writing of this yearbook chapter, WOCATE was too new to have greatly influenced policy making on a global basis. It must be noted, however, that by February 1993, 26 national associations and organizations, representing over 80,000 members, communicated their interest in establishing WOCATE. It has achieved recognition by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) as a sponsoring agency and steering committee member for its "Project 2000+: Scientific and Technological Literacy For All." As the association establishes its membership, WOCATE will have phenomenal potential for impacting associations, educational bodies, and related groups on an international basis.

Anticipated Future Directions. Although WOCATE is a new organization, it has great potential for the technology education profession worldwide. Among the potential future directions are the following:

1. The development of international networks linking universities, colleges, research centers, and pilot projects involved in technology education.
2. The organization and direction of international conferences and human resource development exhibitions/shows for the development and operational dimensions of technology education.
3. The initiation, management, and/or analysis of international congresses for the identification and exploration of trends and innovative solutions in the field of technology education.
4. The organization of educational approaches and development projects for themes relevant to technology education as well as international assessment, strategy seminars, and the exchange of internationally significant developments.
5. The realization of official recognition by appropriate international authorities such as the UNESCO, the World Bank, and the European Community.

The WOCATE has conducted a number of major conferences and has others scheduled. In 1993, for example, the Festival on Technology Education for Elementary Stages, Ages 5–14, was held in Aberdeen, Scotland. Four conferences were scheduled for 1994. These were the following: (a) Technology Education of 14–18 Year Old Students: Strategies, Developments and Trends, (Eindhoven, The Netherlands); (b) Development of Databases for Multidimensional Projects in Technology Education and New Development Strategies and Instructional Technologies for Technology Education (Brussels, Belgium); and (c) Technology Innovation and Management (Banska Bystrics, Slovakia).

RETROSPECT AND A LOOK TO THE FUTURE

The technology education profession has been very fortunate to have the professional support of four councils and two student associations. While this chapter covers significant activities in recent years, the reader should realize that organized groups have provided service to the profession for at least 50 years. The contributions are so significant that one hesitates to think what the profession would be like had they not existed. Each of these groups has focused on a specific area (e.g., elementary, supervisory, teacher education) thereby providing research and service to a wide range of professionals. The emergence of WOCATE provides ample evidence of the spread of interest in technology education in many parts of the world.

The literature is replete with council and association sponsored research and service. These contributions are due to the countless individuals who have given of their time and expertise to help their colleagues at all levels. Teachers, supervisors, and administrators have benefited from these contributions. More importantly, students at all levels, K through graduate school, have had their education enhanced because individuals were willing to share their expertise with the profession through these councils and associations.

It is important to note that while these groups now function independently, almost all of them have a common focus through their affiliation with the ITEA. In some cases this affiliation has a constitutional basis, while in others it is continual dialogue and cooperative spirit that embraces and advances new ideas. In any case, it is clear that the focus is on the need for the advancement of technological literacy for all people.

Optimism concerning the future of technology education and the profession of technology education can be attributed to the potential inherent in these groups. Each has its own identity, goals, and objectives, all of which are consciously designed to advance the field. Long-range plans are in place and are being acted upon diligently. Technology education might best be characterized as a meaningful whole made up of discrete but related parts. With the acceptance, on the part of each council/association, of the study of technology as the discipline base (technology education), the future is very bright. The image portrayed is one of agreement and consistency, yet one that is flexible and capable of change.

As in the past, technology education will rely on the continued commitment of individual members and their willingness to seek agreement in their respective groups. With the advancement of communication systems, the opportunity for rich dialogue on an immediate basis will expand the opportunities for the sharing of ideas. This will occur at all levels—local, regional, national, and international.

It is the author's opinion that the association and councils have been the direct link between theory and practice. The infrastructure is in place for continued success. The future is full of potential for the advancement of technology education as a result of these trends.

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CHAPTER 19

Professional Publications in Technology Education

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Technology education has undergone more change in the past 15 years than at any other time in the history of the profession. The transition from industrial arts to technology education has brought about change in nearly every aspect of the field. New curriculum models and instructional methodologies have emerged, which in turn have led to reconceptualized courses, instructional activities, and facilities. Concurrently, other disciplines, science in particular, have placed increased emphasis on technology—a trend that has provided substantially greater visibility for technology education.

The body of literature that has evolved during this transition is highly significant. On the one hand, the literature of the field has provided a forum for the very dialogue that allowed these changes to transpire. On the other hand, the literature has served to document this transition for future scholars. It is a diverse body of literature that includes professional journals and monographs, publications of the International Technology Education Association (ITEA), textbooks from commercial publishers, yearbooks from the Council on Technology Teacher Education, proceedings from the Technology Symposia, and publications sponsored by the Technical Foundation of America. This chapter examines the contributions of these professional publications during the period from 1980 through 1993.

SERIAL PUBLICATIONS

The serial publications of the profession range from scholarly research journals directed primarily at teacher educators, to the less formal magazine format intended for a much broader audience, including those outside the profession. Each has its own unique features and each has played a significant role in the profession since 1980. Active journals in the field during the transition from industrial arts to technology education include *The Journal of Epsilon Pi Tau*, *The Journal of Technology and Society*, the *Journal of Technology Education*, the *Journal of Industrial Teacher Education*, *The Technology Teacher*, *TIES Magazine*, *SCHOOL SHOP/Tech Directions*, *Manufacturing Forum*, *Industrial Education*, and the *Technology Education News*.

In addition to the obvious function of publishing the literature of the field, the professional journals have provided a service to authors in the field. Editors and reviewers work closely with professionals to hone manuscripts to professional standards, where necessary. The editorial boards have provided many professionals an opportunity to learn about publication "from the inside." Moreover, a few editorial boards of journals such as those of the *Journal of Industrial Teacher Education* and the *Journal of Technology Education* have offered programs on writing for professional publication at annual conferences.

The Journal of Epsilon Pi Tau

J. Streichler (personal communication, March 1, 1993) indicated that *The Journal of Epsilon Pi Tau* is "a vehicle for ideas that pertain specifically to each professional area devoted to education in technology. . . . [It] attempts to highlight commonalities, sharing of knowledge thought to be unique to one but having applicability to other fields such as: Engineering Technology, Industrial Technology, Industrial Vocational-Technical Education, Technology Education, Training and Development, and other closely related areas." The journal made efforts to publish articles from scholars in disciplines such as sociology and history when that work related to the purposes of the journal and, likewise, courted an international perspective. Throughout the 1980s, the journal became increasingly diverse in terms of the types of manuscripts it published. In the beginning of the 1980s, nearly all of the manuscripts came from industrial arts teacher educators. Increasingly throughout the decade, articles began to relate to technical subjects. This trend mirrored a substantial shift that took place in teacher education programs during the decade. During the 1980s, many if not most of what had been industrial arts teacher education programs evolved to become primarily industrial technology programs. As their emphasis shifted from preparing teachers to preparing entry level professionals in technical fields, the flavor of the manuscripts published in *The Journal of Epsilon Pi Tau* shifted, to some extent, in this direction.

Jerry Streichler has served as the sole editor of *The Journal of Epsilon Pi Tau* since 1977, while concurrently serving as both faculty and administrator in the College of Technology at Bowling Green State University. The reviewing process, described as one preliminary review followed by two or three additional readings, allows Streichler more editorial control than editors of other journals, such as the *Journal of Industrial Teacher Education* or the *Journal of Technology Education*. During the 1980s, the College of Technology in which Streichler served as dean, had, like many institutions in the field, shifted its emphasis from teacher education to preparing graduates for industry employment. This may help to explain the somewhat more eclectic mix of articles that appeared in the journal during the 1980s.

At an address presented at the 1992 ITEA conference, Streichler indicated that the Epsilon Pi Tau Board of Directors was pondering future directions for the journal. One such change came with the Winter/Spring 1993 issue, which carried a new title: *The Journal of Technology Studies*. The name was chosen by the Board of Directors of Epsilon Pi Tau, in part because it was believed the "profession would be better served by a title that more specifically called out a field or disciplinary interest" (Streichler, 1993, p. 2). In explaining the reasons for the name change, Streichler indicated that *The Journal of Technology Studies* would continue to be "devoted to education for technology and the technology professions" (p. 3).

The Journal of Technology and Society

In the mid 1980s, a need was perceived by the Board of Directors of the International Technology Education Association (ITEA), to establish a scholarly journal it could call its own. While both the *Journal of Industrial Teacher Education* and *The Journal of Epsilon Pi Tau* had served the industrial arts profession well as outlets for professional publications, neither was focused solely on technology education and both drew editorial content from other technical fields. Moreover, there existed an abundance of manuscripts that had been submitted to and accepted for publication in *The Technology Teacher*. A number of these were thought to be more appropriate for technology teacher educators than classroom teachers at a time when *The Technology Teacher* was trying to focus on the latter constituency.

Given those concerns, the ITEA Board of Directors at its spring 1984 meeting approved a motion from E. Keith Blankenbaker, the ITEA board representative for the American Council for Elementary School Industrial Arts, to establish a new professional journal. The journal was to be published out of The Ohio State University, where Blankenbaker served on the faculty of the Department of Industrial Technology Education. The ITEA Board of Directors turned over to him a number of manuscripts for publication in the new journal. A year later, the board approved a name for the journal, *The Journal of Technology and Society (JTS)*. The name fit with the emphasis in the field at the time on the interrelationships of technology with social and cultural issues. The ITEA Board of Directors had provided modest funding for the start up of the *JTS*, as did the Council on Technology Teacher Education (CTTE), who also formally approved the journal's start, since it was to be directed primarily at teacher educators in the field. Since the manuscripts to be used for the first issue had already been reviewed and accepted by *The Technology Teacher* reviewers, the editorial review board for *The Technology Teacher* was named editorial board for the new *JTS*, thereby establishing a dual reviewing responsibility for those individuals. Kendall N. Starkweather, Executive Director of ITEA, was named editor in chief and E. Keith Blankenbaker became the managing editor.

For a variety of reasons, *The Journal of Technology and Society (JTS)* got off to a slow start. Volume 1, No. 1 was published in Winter, 1987. Since the *JTS* was not a membership benefit of either the ITEA or the CTTE, there were few subscribers to the new journal. Publication problems resulted in a delay for the second issue, and Volume 1, No. 2 never appeared. The second issue, Volume 2, No. 1 was published in Autumn 1988, followed shortly thereafter by Volume 2, No. 2 in Winter 1989. Early in 1989, a list of 57 *JTS* subscribers was transferred to Mark E. Sanders of Virginia Polytechnic Institute & State University, editor of the newly created *Journal of Technology Education.*

Journal of Technology Education

Mark E. Sanders and James E. LaPorte, faculty in the Technology Education Program at Virginia Polytechnic Institute & State University, submitted a proposal to ITEA to assume publication of *The Journal of Technology and Society (JTS)* as a result of the problems incurred with that journal. In October, 1988, the ITEA Board of Directors and CTTE Executive Committee approved this move and the *Journal of Technology Education* was born. Sanders was named editor and LaPorte became the associate editor. As a condition of the original proposal, the name was changed to the *Journal of Technology Education* (JTE) at the spring, 1989 board meeting. As was the case with the *JTS*, the *JTE* was not intended as a general membership benefit of either the ITEA or CTTE. Subscribers paid for the *JTE* in addition to their regular dues.

In October, 1989, Volume 1, No. 1 was distributed to the original 57 *JTS* subscribers, a small number of new subscribers, and two copies were mailed to each department head in the *Industrial Teacher Education Directory* as a way of promoting the new journal. Subscriptions increased steadily throughout the first few years of publication and by the spring of 1993, there were approximately 525 paid subscribers from 13 countries throughout the world.

Since its initial publication, the intent of the *JTE* has been to focus specifically on technology education research, theory, and practice. The editorial policy is very clear in this regard. Thus, while the *JITE* and *The Journal of Epsilon Pi Tau* were becoming increasingly diverse in their editorial policy, the *JTE* remained focused solely on technology education.

The *JTE* is published in the fall and spring of each year. Each issue consists of approximately 80 pages, with five regular sections: "From the Editor," "Articles," "Book Reviews," "Editorials," and "Miscellany." Other sections that appear intermittently in the *JTE* include "Guest Articles," "Reactions," and "Research Digests." It is, in effect, patterned along the lines of the *Journal of Industrial Teacher Education*, but focuses only on technology education. The different sections provide opportunities for authors to contribute manuscripts ranging from short book reviews and editorials to comprehensive reports of research.

Throughout the first four years of publication, the articles published were split almost equally between those that were conceptual and those that were research based. They included a wide range of issues representing the diverse interests of the field. Technology education curriculum was the most frequently addressed topic, owing in part to Volume 3, No. 2, which was a special theme issue on curriculum.

Since the inception of the *JTE*, a concerted effort has been made to provide a broad base for the dialogue on technology education. Editorial board members from Great Britain and The Netherlands, where much was happening with regard to technology education, assisted with this mission. Similarly, a member of the Science, Technology, and Society community was recruited for the editorial board to provide a perspective not generally found among technology education professionals. The "Book Reviews" section intentionally avoided books written by people within the field, in order to avail readers of some titles they might not ordinarily run across in their regular professional reading. Moreover, the editor solicited "Guest Articles" from international authors and authors outside the field.

A highly significant and perhaps the most unique aspect of the *Journal of Technology Education (JTE)* was the introduction of an electronic version with the Fall, 1991 issue. Electronic copies of the *JTE* were provided free of charge via a listserv (ASCII format) and an FTP site (Postscript format) on the internet. When the *JTE* first began publishing its electronic version, it was one of only a handful of refereed journals in the world to be published electronically. It was an immediate success on several levels. The *Chronicle of Higher Education* (1992) ran a story about it and it was listed in a feature article in the Higher Education Product Companion (Volume 2, Number 2, April 1993). More importantly, people from all over the world immediately began downloading articles from the *JTE*. The vast majority of these individuals were not from within the field as most were reading about technology education for the first time. It thus became a promotional tool for the profession, reaching persons outside the field who likely had never heard of technology education.

The experiment was deemed a success and by winter of 1992, all back issues of the *JTE* had been electronically archived on the FTP site. Thus, anyone with internet access could download any article ever published in the *JTE*; a first in the history of refereed journals. In addition, the *JTE* may have been the first refereed journal to distribute a postscript (in addition to ASCII) version, thus allowing readers to download and print to a postscript laser printer, which resulted in a version with excellent quality text and graphics. By the spring of 1993, more than 1,000 individuals from all over the world had subscribed to the electronic version of the *JTE*, about twice the number of hard-copy subscribers at the time. In addition, between January and October 1993, the electronic *JTE* had been accessed 4,123 times via FTP, 4,051 times by Gopher searchers, and 1,465 times by Wide Area Internet Search (WAIS) searches, the latter resulting in 10,161 electronic retrievals (Powell, 1993). The electronic version of the *JTE* had become a worldwide educational and promotional tool for the technology education profession.

Journal of Industrial Teacher Education

The *Journal of Industrial Teacher Education (JITE)*, published quarterly by the National Association of Industrial and Technical Teacher Educators (NAITTE), has enjoyed a reputation for scholarly publication in the broad field of industrial education. The NAITTE membership provides the primary audience for the *JITE*, and the NAITTE membership is considerably wider than technology education. The National Association of Industrial and Technical Teacher Educators first constitution described the membership as "all persons who devote half or more of their time to teacher training in Industrial Education, either general or vocational" (Evans, 1988, p. 23). This was revised in 1950 to read "all persons interested in problems relating to the training of teachers for the field of industrial arts or industrial education" (p. 23). In 1967, the constitution added Health Occupations and Technical Education membership categories (health occupations was dropped in 1980). In 1985, the constitution added Industrial and Military Training as another membership constituency. Thus, the *JITE* currently serves four membership constituencies within NAITTE: technology education, technical education, trade and industrial education, and industrial and military training.

The *JITE* began publication in 1963, which immediately increased the membership in the association. In the early 1980s it was very much a research journal, with its pages almost exclusively given to reporting research findings. In the winter of 1984, under the editorship of David L. Passmore of Pennsylvania State University, the *JITE* broadened its format to include "At Issue," "Comments," and "Reactions" sections, an effort designed to create more publication opportunities and a greater dialogue than had previously occurred. Passmore also began to invite noted scholars outside the profession to publish "Guest Articles" in the *JITE*, thus bringing some new perspectives to the *JITE* readers.

It is not surprising that the *JITE* content covers the broad spectrum of industrial education, both general and vocational, and training given the diversity of NAITTE's membership. While the editorial policy of the journal is inclusive of the four areas represented by its constitution, all of the editors since 1980 have had vocational trade and industrial education backgrounds. Similarly, the NAITTE leadership has been comprised predominantly of vocational trade and industrial education professionals. Thus, while the editorial policy of the *JITE* is open, and many articles relating to technology education have been published therein, it has not been perceived as a technology education journal by technology teacher educators. The perception that the *JITE* is largely a vocational journal may be responsible, in part, for the sharp decline in NAITTE membership (and therefore *JITE* readers) experienced in the early 1990s. This decline took place at the same time the newly established *Journal of Technology Education* (JTE) experienced a very positive subscription growth curve.

In 1979, the *JITE* began recognizing authors with Outstanding Manuscript Awards for exemplary articles published in the *JITE*. This program was initiated as a means of recognizing and/or improving the level of scholarship in the field. The Outstanding Manuscript Awards may be issued annually in each of three manuscript categories that describe the basis of the article: research, concepts, and dissertation. Despite the journal's title, nearly all of the manuscripts deal with secondary school level issues and research rather than post secondary/teacher education issues. Only 10% of the Outstanding Manuscript Awards have gone to articles relating to teacher education (Evans, 1988).

The *JITE* made significant efforts to improve the scholarship of its authors. In the early 1980s, then editor David L. Passmore instituted a mentoring program in which authors of promising, but unpolished, manuscripts were paired with experienced authors. The pair worked back and forth until the manuscript was deemed acceptable for publication in the *JITE*. While mentoring was not pursued as formally by all subsequent editors, the *JITE* has continued to provide extensive feedback to authors to assist them in the revision of promising manuscripts.

Due to a significant decline in NAITTE membership between 1990 and 1993, the immediate future of the *JITE* is somewhat dubious. Evans (1993) suggested ominously, "if NAITTE were to stop funding *all* of its other activities, the current and projected budgets for the *JITE* would consume essentially all the current income from dues and NAITTE could no longer exist" (p. 34). He recommended cutting back publication from four issues to three and assessing authors a page cost (about $27/page). T. J. Walker (personal communication, March 5, 1993) expressed similar concerns: "American Technical Publishers, Inc. no longer underwrites *JITE*'s production costs. If some alternative is not found the form of the Journal will probably be affected. That could mean fewer issues, or some other modification."

The Technology Teacher

The Technology Teacher (TTT) has played a special role in the transition from industrial arts to technology education. Produced at the home office of the International Technology Education Association (ITEA), it provides the association with a means of communicating to its membership ideas and information that the Board of Directors and Executive Director deem important. Throughout the 1980s, they exercised the opportunity to take a proactive role in leading the profession. The Executive Director of the ITEA, Kendall N. Starkweather (personal correspondence, February 2, 1993) said of *The Technology Teacher's* role in the 1980s, "[it showed] where we were going and not where we had been."

The Technology Teacher has been a key communication device both within and beyond the profession. More than any other single publication, *The Technology Teacher* keeps readers informed of the ideas, issues, and trends in the profession. A concerted effort was made not to focus on the woodworking and metalworking projects that had been the mainstay of the industrial arts education era (and the publications of that era). Rather, *The Technology Teacher* took a broader view, publishing articles by and for technology teachers, teacher educators, supervisors, and students.

The editorial structure of *The Technology Teacher* facilitated its role as a change agent in the transition from industrial arts education to technology education. Beginning with Starkweather's stewardship at the ITEA, the Executive Director served as editor-in-chief and the editor was a full-time employee of the ITEA. As a result, most of the editorial decisions were made in-house.

In a sense, *The Technology Teacher (TTT)* is two publications in one. On the one hand, it contains refereed articles that are reviewed by an editorial review board. Those manuscripts recommended for publication are forwarded to the editor and readied for publication. These articles deal with a wide range of educational issues and practice. Articles accepted for publication have been consistent with the ITEA's view of the role of the *TTT*. Refereed articles typically comprise about one third of the pages in *The Technology Teacher*. The remainder of *TTT* is made up of content governed by the ITEA staff. Most of these appear regularly, such as "Perspective," "Resources in Technology," and "Technology Learning Activities." These sections provide the association with a means of keeping progressive ideas in front of the membership. For example, the 1981 interview entitled "Should There be a Name Change for Industrial Arts?" (Bensen, Householder, & Phillips) was indicative of the way in which ITEA was able to help move the field toward technology education. Starkweather asked three prominent leaders to answer five questions regarding the need for a name change. Not surprisingly, all three were in favor of a new name for the profession, though all three were most tactful in this regard. Articles such as this allowed *The Technology Teacher* to encourage progression rather than stagnation in the field. Other examples of articles that appeared in *TTT* in the early 1980s and helped move the field toward technology education included the following:

- Hales, James A. and Snyder, James F. (1982, February). "Jackson's Mill Industrial Arts Curriculum Theory: A Base for Curriculum Derivation."
- Hacker, Michael and Barden, Robert. (1983, March). "A Systems Approach to Technology Education."
- Martin, G. Eugene. (1983, April). "Curriculum Implications for Technology Education-1990."
- Starkweather, Kendall. (1983, May/June). "AIAA: Pioneering Leadership in Industrial Arts/Technology Education." [Note the use of "industrial arts/technology education" in the article, followed by a name change to *The Technology Teacher* with the September/October 1983 issue.]
- No Author. (1984, February). The *TTT* Ballot: Question: Should Industrial Arts Education Have a National Curriculum Direction?
- Bensen, M. James. (1984, May/June). "Educational Research-Study of a Name Change for the AIAA."

Each issue opens with "Perspective," an editorial section greeting the reader up front. While the "Perspective" is not written by the ITEA staff, it is solicited and selected by ITEA, which allowed them to present a consistent voice during the transition from industrial arts to technology education. There was room, however, for differing approaches to the transition, as reflected by two "Perspective" titles: "Technology as the Content Base for Industrial Arts (Ritz, September/October 1981), followed a few months later by "Industry as the Content Base for Industrial Arts" (Wright, January, 1982).

A broad look at the content of *The Technology Teacher* throughout the 1980s and the 1990s reveals some general trends. The majority of authors were university faculty, yet the majority of content related to secondary programs and issues. Interpretations of what technology education is and should be were commonly featured. Articles on the integration of new technologies into the curriculum as well as more general discussions of curriculum were staples of *The Technology Teacher*. Articles highlighting exemplary programs, including elementary programs, also appeared regularly. An increasing number of articles describing international approaches to technology education, particularly design and technology in the United Kingdom, began to show up as well, as did articles highlighting the integration of technology education with other school subjects.

Beginning with the September, 1982 issue, "Resources in Technology" became a regular section, designed to serve as a technical resource for technology teachers. It contains information one might find in technical publications in other fields. "Technology Learning Activities" (TLAs) section replaced the older "Project Ideas" section. The TLAs were patterned on the design brief borrowed from the United Kingdom. The problem-solving nature of the TLAs is consistent with one of the most evident trends in technology education—a move away from the project method toward the problem solving method as a means of instruction. One could say *The Technology Teacher* merely reported this trend, but it's more accurate to suggest that the "Technology Learning Activities" section in *TTT* helped to create the general acceptance of the technological problem solving method in technology education.

A number of other sections in *TTT* serve to communicate the ongoing activities of the ITEA and events of interest to the profession. These include "Reviews," for book and media reviews; "Research Briefs," which are articles reviewed by the ITEA Research Committee; "Business/Education Connection," which is generally an article describing connections made between business and a technology education program; "Technology Notes," which include such things as news on people and associations, free materials, catalogs, and a calendar of upcoming events; "Advertiser's

Index;" and "Product News," describing new products of interest to technology teachers.

There are also some sections that appear once each year in *The Technology Teacher* pertaining to the business of the ITEA. The ITEA (and more recently, Foundation for Technology Education) Financial Reports appear in the January issue. A list of Outstanding Young Technology Educators and Application Guidelines for the following year's ITEA conference are published each March, and a listing of technology education degree granting institutions can be found in the April issues.

TIES Magazine

TIES Magazine (TIES) makes no pretense of being a journal in the academic sense. The four-color format and extensive use of graphics throughout *TIES* gives it the look and feel of a consumer magazine. Like its format, the editorial content of *TIES* is the most avant-garde in the field. The vision of technology education projected by *TIES* borrows heavily from the design and technology movement in the United Kingdom. In this respect, *TIES* was instrumental in developing interest in and acceptance of the design and problem-solving activities common in British programs.

In the early 1980s, Ronald D. Todd, then a faculty member of the Department of Technology and Industrial Education at New York University Washington Square initiated the concept for *TIES* magazine. The idea evolved through discussions with Pat Hutchinson, who would later become editor in chief. In 1986, J. Michael Adams, Dean of the College of Design Arts at Drexel University, offered support for the idea, and two years later, with Todd serving as the executive editor and Hutchinson as editor in chief, the first issue of *TIES* was published and distributed to the field. In the spring of 1993, *TIES Magazine* moved to the School of Technology at Trenton State College. Since its inception in 1988, *TIES* has found its way not only to technology teachers, but to art, science, and vocational educators as well.

Most of the articles published in *TIES* are invited and a significant number of them are written by the staff. This approach allows the editors to create the sort of magazine they envisioned in the early 1980s. Pat Hutchinson (personal communication, February 15, 1993) described *TIES* as providing "a combination of technical information, a forum for discussion of education issues, a model of a more student-centered, process-based approach to instruction, a vision of our readers as global citizens and a wide range of interdisciplinary subject matter." *TIES* intentionally tried to create the image, both within and beyond the field, that technology education really was something new and different from industrial arts education.

One of the features that differentiates *TIES* from other publications in the field is its emphasis on the design component of technology education. The inside cover of each issue reminds the reader of the following:

> *TIES* provides teachers with up-to-date resources for the development of a hands-on, design-based technology education curriculum. *TIES* promotes the potential for innovation and entrepreneurship in students by providing models, strategies and examples of design, critical thinking, creativity and problem-solving, and through spotlighting professional and student designers and their products.

TIES is free to its readers, so it relies heavily upon its advertisers and private funding sources for support. This provides a certain autonomy on the one hand, but poses some limitations as well. While *TIES* management and readers prefer it be longer and published more frequently, this requires additional funding. *TIES* enjoys the widest distribution of any publication in the field. Yet its future seems largely dependent upon its ability to maintain financial support. If advertisers continue to feel they are "getting their money's worth" in advertising, and Drexel University and Trenton State College maintain their support, *TIES* may continue to grow and flourish. On the other hand, either a change in funding status or editorial staff could result in significant changes in the format and/or substance of *TIES*.

SCHOOL SHOP/Tech Directions

As is apparent to most professionals in the field, the path from industrial arts to technology education has been neither clear nor direct. During the past two decades, the field has had a number of "camps," including, (a) industrial arts teachers who emphasize the craft aspect, (b) industrial arts teachers who emphasize the industry aspect, (c) industrial arts teachers who emphasize the vocational aspect, (d) technology teachers who emphasize industry, and (e) technology teachers who emphasize design and problem solving. *SCHOOL SHOP*, as it was called throughout the 1980s, appealed primarily to industrial arts teachers who had either an industry or vocational orientation. Today, this publication is known as *Tech Directions* and it still focuses on "linking education to industry," as it states on its cover. This translates to a format that caters to the vocational trade and industrial education component of its readership. The majority of articles in *SCHOOL SHOP/Tech Directions* have been descriptions of projects and activities for high school unit shop teachers, so it has played a limited role in the transition to technology education.

With the onslaught of computers, the content gradually became more technical, but the orientation was still more vocational than general education. In the 1990s, *Tech Directions* began to gear its content more toward upper high school and community college levels than was previously the case. With the field of technology education currently moving to more broadly conceived curriculum models, *Tech Directions* seems to be concentrating less on those readers and focusing on the trade and industrial education vocational niche that it has maintained.

Manufacturing Forum

At the 38th conference of the American Industrial Arts Association in Des Moines, Iowa, a group of industrial arts teachers who felt strongly about the role of manufacturing courses in the curriculum decided to form the Manufacturing Educators Consortium. The group decided that "the primary function of the Consortium would be to develop a publication to serve as a vehicle for the exchange of philosophical positions and practical information related to the teaching of manufacturing" (Barella, Smith, & Wright, 1976, p. 2). Accordingly, the first issue of this new publication was released in the fall of 1976. True to its pledge, the *Manufacturing Forum* became a place for manufacturing educators to discuss methods and philosophical approaches to the teaching of manufacturing. Since its initial publication, it has helped to define one of the major content clusters in the field.

During the first three years, Richard Barella, Donald F. Smith, and R. Thomas Wright alternated editorial responsibility for the three issues that were published annually at Ball State University. An editorial advisory board was established to assist with the reviewing process. In the fall of 1980, Smith and Wright served as co-editors on each issue and by the fall of 1982, Wright became the sole editor. The publication was packed with halftones and line art depicting, in great detail, specific practices that worked. Regular features evolved, including an editorial section, a tooling feature that graphically depicted a tooling jig or fixture, and a featured product, which was a plan for a product that was suitable for manufacturing.

In the fall of 1986, Richard D. Seymour took over as editor of the *Manufacturing Forum*. Apparently, by 1988, most manufacturing teachers thought what needed to be said about manufacturing had appeared in the *Forum,* as fewer manuscripts were submitted for publication than had been the case during the first decade of publication. The editors consulted the editorial advisors and the group decided to cease publication of the *Manufacturing Forum* in 1988. The success of the *Manufacturing Forum* prompted Frank R. Trocki and Ronald E. Jones of Eastern Illinois University to attempt a similar *Communication Forum* in 1984 for communication technology teachers. Though the inaugural issue indicated it would be published twice annually and subscriptions were solicited, the first issue was written primarily by students at Eastern Illinois University and a second issue was never produced.

Industrial Education

In the early 1980s, *Industrial Education* tried to appeal to a broad audience of classroom teachers. Its masthead read "The Magazine for Industrial Arts, Vocational, and Occupational Education." Up until 1979, *Industrial Education* included three regular departments in its "Articles" section: Materials and Processes, Power and Energy, and Visual Communications. Though these subsections did not always appear, they were a concession of sorts to the cluster organizers that had become popular in the 1970s. In the fall of 1980, the magazine dropped these organizers, a foreshadowing, perhaps, of the way in which *Industrial Education* would drift away from the technology education movement in the 1980s.

Industrial Education had been a magazine that many industrial arts teachers read enthusiastically for decades for activity and other instructional ideas. As the 1980s unfolded, the editorial philosophy of *Industrial Education* seemed to digress from the evolving ideas in technology education. In April of 1983, the Cummins Publishing Company purchased the magazine and began to "give the traditional programs a technological perspective without abandoning the fundamentals" and slant their content away from middle school toward high school and college levels ("An Idea," 1985, p. 5). This translated into more high tech articles for the vocational trade and industrial education teacher. They focused on specific areas such as "Graphic Arts, Automotives, Material Technology, Drafting and Design, and Power Mechanics" ("An Idea," p. 37), rather than the broader content clusters of technology education.

In the fall of 1984, Andrew Cummins replaced longtime editor John Feirer, who also served as Chair of the Industrial Technology and Education Department at Western Michigan University, and *Industrial Education* continued its pursuit of the high tech vocational trade and industrial education readership. Some of the authors and articles were from and about technology education, but the flavor was more technical and vocational and the advertising in particular was geared in that direction. In February of 1986, Cummins became editorial director and a new editor was employed. It went to one other editor in May of 1989 before returning to Cummins in September 1989. In 1990, *Industrial Education* ceased publication.

Technology Education News

In December 1984, Davis Publications and the American Industrial Arts Association (AIAA) co-sponsored the *Technology Education News (TEN)*. This was a three-color newsletter to the profession. The *TEN* served two purposes. First, it provided an expedient means of getting timely information (including the name Technology Education) to the AIAA membership. In addition, it provided visibility for Davis Publications, whose name appeared below the masthead along with the name of the AIAA.

As its name implies, the *TEN* carried news of the day. Headlines in the first issue help to describe its content and included the following: "The 1985 San Diego Program" [AIAA Conference], "SME and AIAA Form Partnership to Support Technology Education," "Los Angeles County Schools Change Name to Reflect Technology" [Industrial Technology], "New AIAA Publications;" "AIAA Action," "Criteria for Identifying Model Programs," "AIAA Established First Institute for Technology Education," and "IEEE Supports Technology Education." In addition, there were curious boxes of information titled "Using Technology" (e.g., one described how chocolate ice cream was made) and "Do You Know" (e.g., one described the first dental drill). Four issues were published in Volume 1 between December 1984 and September 1985, but it became somewhat sporadic in 1986. Sometime in 1986, the publication was quietly terminated.

COUNCIL ON TECHNOLOGY TEACHER EDUCATION YEARBOOKS

The yearbook series of the Council on Technology Teacher Education (CTTE) occupies a unique niche in the scholarship of the field. As with the current issue, these yearbooks provide a more thorough overview of topics deemed timely and important in the field than any other format. Many of the yearbooks have fulfilled a need as textbooks in college classrooms.

The process used to generate the yearbooks has much to do with the nature of the overall series. Each year, yearbook proposals are solicited by the CTTE Yearbook Committee. These proposals are submitted by a would-be editor who has assembled a team of professionals in the field, each of whom has agreed to write a chapter in the yearbook. The individual authors are selected for their proven scholarship and expertise with respect to the proposed yearbook topic. The yearbooks are published with considerable editorial and production support of Glencoe/McGraw-Hill, a tradition since the inception of the series.

The proposals are circulated to the committee prior to the annual conferences of the International Technology Education Association. After reviewing these proposals with would-be editors, the committee meets in executive session to debate the merits of each proposal. They select those they wish to see published and establish a time line for the editor/authors. As a result of this process, CTTE yearbooks tend to focus on issues that are deemed critical by a group of professionals in the field, rather than by an individual. A listing of all the CTTE yearbooks ever published is found in the front part of this yearbook.

TECHNOLOGY EDUCATION SYMPOSIA PROCEEDINGS

Charleston, Illinois was an unlikely birthplace for an annual symposium series of national interest. In 1980, however, Ronald E. Jones and John R. Wright approached longtime technology education advocate-turned-dean Donald P. Lauda with an idea for a symposium that would further the cause of technology education. With Lauda's support, they hosted the first Technology Education Symposium at Eastern Illinois University in Charleston, Illinois. Lauda (Wright, 1980) spoke to the purpose of that first symposium in an opening address to the participants:

> The purpose of this conference is not to seek approbation in the discipline. As you well know, our discipline is far from reaching agreement in its philosophy or demonstrated actions. As I see it, this conference can aid in the process of convergence as we seek new directions for helping students of all ages. (p. 2)

Symposium III took a little different approach than the previous two in that it was "designed to provide practical classroom-oriented suggestions for teaching Industry/Technology Based Industrial Arts" (Wright, 1982 , p. 3). The design of the symposium provided a keynote address followed by two program interest sessions. At each interest session, two leaders in their areas of expertise presented an answer to "What Should Be Taught and How Could It Be Organized." The interest sessions concentrated on major curriculum areas: communication, construction manufacturing—enterprise, manufacturing—material processing, and transportation—power/energy.

The seventh symposium in the series moved east to California University in Pennsylvania. As Andre and Lucy (1985) stated, "The symposium traveled away from the four midwestern states that served as earlier hosts. This is additional evidence that the movement for technology education is growing and spreading" (p. 1). There were 244 persons from 23 states who attended the symposium, an indication of the interest in the format. Donald Maley's keynote address (Andre & Lucy, 1985) underscored the keen interest by the profession: "There has never been a more appropriate time than the present for aggressive, imaginative, and concerted action aimed at *establishing technology education as an integral and valid component of education for all youth and adults*" (p. 3).

In a departure from previous tradition, Symposium VIII issued a "call for papers" well in advance of the symposium, refereed those papers, and distributed the completed proceedings to all in attendance at the conference (Sanders, 1986). This was made possible by using then state-of-the-art electronic pagination and publishing techniques available at Virginia Tech, which hosted the conference. The call for papers was an attempt to open up the symposium to a broader audience. Papers from the United Kingdom and The Netherlands were accepted, as were several from professionals outside the field.

The themes for the symposia were selected by institutions wishing to host them. Though the Technical Foundation of America sponsored many of the symposia, the series grew with a life of its own. There were no formal guidelines governing it from year to year, and as a result, no proceedings were published in several instances. Without formal sponsorship and with the general acceptance of the technology education paradigm, interest in the symposia seemed to be waning in the early 1990s, and the symposia and accompanying proceedings may soon become a thing of the past.

The following listing of Technology Education Symposium themes provides a sense of the important issues and topics of the era:

- Wright, J. R. (Ed.). (1980). *Proceedings of the first technology education symposium*. Charleston, IL: Eastern Illinois University.
- *Technology education symposium II: The context of technology education*. (1981, May). Proceedings of the technology education symposium II. Menomonie, WI: University of Wisconsin Stout.
- Wright, R.T. (Ed.). (1981). *Industrial/technology education symposium III proceedings*. Muncie, IN: Ball State University.
- Andrews, W., & Miller, L. (Eds.). (1982). *New technologies and implications for curriculum*. Proceedings of the technology education symposium IV. Normal, IL: Illinois State University.

- Technology Education Symposium V was held at The Ohio State University, though no proceedings were published.
- Scarborough, J. D. (Ed.). (1984). *Proceedings technology education symposium VI*. DeKalb, IL: Northern Illinois University.
- Andre, N., & Lucy, J. (Eds.). (1985). *Technology education: Issues and trends*. Proceedings of technology education symposium VII. California, PA: California University of Pennsylvania.
- Sanders, M. E. (Ed.). (1986). *Technological literacy: An educational mandate*. Proceedings of the technology education symposium VIII. Blacksburg, VA: Virginia Polytechnic Institute and State University.
- Robb, J. L., & Kozak, M. R. (Eds.) (1987). *Contexts, elements, levels: 50 years later, 2030 A.D.* Proceedings of the technology education symposium IX. Denton, TX: North Texas State University.
- Gilberti, A. F. (Ed.). (1988, October). *Technology: An international perspective*. Proceedings of the technology symposium X. St. Cloud, MN: St. Cloud State University.
- Erekson, T. L., & Johnson, S. D. (Eds.). (1989, September). *Technology education: An interdisciplinary endeavor*. Proceedings of technology education symposium XI. Urbana-Champaign, IL: University of Illinois.
- Tracey, W. E. Jr. (Ed.). (1990). *Technology education: The teaching and learning environment*. Proceedings of the technology education symposium XII. New Britain, CT: Central Connecticut State University and Worcester, MA: Davis Publications.
- Wright, P. H. (Ed.). (1991). *Technological impacts*. Proceedings of the technology education symposium XIII. Terre Haute, IN: Indiana State University.
- Hauber, G. D., Litowitz, L. S. & McCade, J. (Eds.) (1992). *Teaching problem solving versus content in technology education*. Proceedings of the technology education symposium XIV. Millersville, PA: Millersville University.

COUNCIL ON TECHNOLOGY TEACHER EDUCATION MONOGRAPHS

The Council on Technology Teacher Education (CTTE) monograph series is the result of the work of the CTTE Publications Committee. The committee solicits and reviews proposals for monographs and works with authors through a reviewing process, to see them through the publication process. No CTTE monographs were published between 1983 and 1991, when much of the transition activity was occurring, hence, their role in shaping the transition was essentially nil. In 1991, three monographs that focused on technology teacher education, graduate education, and facilities were released.

The seven titles included in the monograph series since 1980 are the following:

- Maley, D. (1980). (CTTE monograph 7). *Industrial arts builds the skills in people that America needs.*
- Koble, R. (1980). (CTTE monograph 8). *Doctoral programs in industrial arts education: Their ranking and distinguishing characteristics.*
- Jones, R. E. (Ed.). (1983). (CTTE monograph 9). *Work and education in the eighties.*
- Wright, J. R. (Ed.). (1987). (CTTE monograph 10). *A primer for selecting graduate programs.*
- Henak, R. (Ed.). (1991). (CTTE monograph 11). *Elements and structure for a model undergraduate technology teacher education program.*
- Wright, J. R. (Ed.). (1991). (CTTE monograph 12). *Essential elements of a quality graduate technology education program.*
- Polette, D. (Ed.). (1991). (CTTE monograph 13). *Planning technology teacher education learning environments.*

ITEA PUBLICATIONS PROGRAM

The proactive nature of the International Technology Education Association (ITEA) was evident in their publications program throughout the 1980s and into the 1990s. *Technology Education: A Perspective on Implementation* (International Technology Education Association, 1985) served to initiate this effort. This and several other similar publications to follow began to promote a rationale and framework that had been evolving since the publication of William E. Warner's *A Curriculum to Reflect Technology* some four decades earlier (Warner, 1947). Section 1 of *Technology Education: A Perspective on Implementation* set the table for the remainder of the document and included three essays by noted professionals: Ernest Boyer's "A Perspective on Education," Walter Waetjen's "People and

Culture in Our Technological Society," and James Johnson's "The Nature of Our Technological Society." The other essays served to familiarize the industrial arts education community with the ideas and practices associated with technology education. The field was wrestling with conflicting viewpoints while trying to promote a contemporary vision of technology education. This document was the ITEA's way of beginning to provide some direction and clarity in that regard.

Technology Education: A Perspective on Implementation was very successful in that it began to promote a somewhat unified view to a broad audience within the field. It was cited regularly and often in articles and papers presented throughout the 1980s. Its success led to the publication of a sequel, *Technology: A National Imperative*. This was written to bring "attention to the increasingly important role that technology plays in our society and how it affects our everyday existence" (Technology Education Advisory Board, 1988, Foreword). In addition to essays on the nature of technology and our technological society, it addressed the technology education curriculum and the role it plays in our schools. Ending with a "Call to Action" essay, the document was a useful tool to communicate the vision of technology education to those outside the profession as well as those within it.

With the transition from industrial arts to technology education in full swing in the late 1980s, there was an urgent need for documentation of outstanding technology education programs in the field. This documentation was needed to illustrate to those both inside and outside the field just what a technology education program should be. There began to be some consensus on what the curriculum model should look like, but translating that into a viable program in a real school was a different matter entirely. *Technology Education in Action* provided an overview of 11 middle schools and high schools throughout the country that were identified as having exemplary technology education programs.

Everyone who attended the opening general session of the ITEA conference in the spring of 1989 received a copy of *Technological Problem Solving: A Proposal* (Waetjen, 1989). This ITEA publication signaled the most significant change in methodology brought about by the transition to technology education: the move from the project method of industrial arts to the problem-solving method. The problem-solving method has become nearly synonymous with technology education and this publication was helpful in describing the fact that "problem solving can and must be taught" (p. 10) in technology education.

The ongoing need to justify and clarify technology education was motivation to continue with publications of that kind in the 1990s. *Technology Education and Behavior* (Waetjen, 1992) was another publication of the

Technology Education Advisory Council, though the two essays it contained were both written by Walter Waetjen, President Emeritus, Cleveland State University. The ITEA's Task Force on Professional Development produced two publications on teaching strategies for technology education: *Approaches* (Edmison, 1992a) and *Delivery Systems* (Edmison, 1992b).

TECHNICAL FOUNDATION OF AMERICA PUBLICATION SUPPORT

Though the Technical Foundation of America did not act as publisher, the Foundation financially supported the development of a number of publications during the transition to technology education. These were subsequently published by the International Technology Education Association. They included *Technology Education: A Global Perspective, A Conceptual Framework for Technology Education, Critical Issues in Technology Education, Technology: A National Imperative*, and the *Jackson's Mill Industrial Arts Curriculum Theory.*

The significance of *Jackson's Mill Industrial Arts Curriculum Theory* has been apparent since its initial release in 1981. This document represented the consensus of a group of 21 professionals in the field with regard to a curriculum model for the profession. (See Chapter 7 for a more complete description of this project.) Its purpose was to "provide rationale and direction for the future of industrial arts from which we might all find a point of view" (Snyder & Hales, 1981, p. ii). The *Jackson's Mill Industrial Arts Curriculum Theory* came at a time when the field was split in its perspective about its future. There were some who felt industrial arts should remain forever, some who thought content should be derived from industry, some who thought technology provided the basis for a new discipline, and some who thought method was the important issue. The field was having a difficult time reaching consensus, and this document helped to forge a compromise of sorts among the various camps in the profession. Just as it was intended, the *Jackson's Mill Industrial Arts Curriculum Theory* helped to provide direction for nearly all curriculum development in the 1980s. By the end of the decade, the profession was much more homogeneous in its vision of technology education than it had been at the beginning of the decade, and the *Jackson's Mill Industrial Arts Curriculum Theory* played a key role in establishing that relative homogeneity.

The consensus building model had worked so well with the *Jackson's Mill Industrial Arts Curriculum Theory* that the Technical Foundation of America funded a similar project in 1990. The framework for technology education had come a long way during the 1980s, but there were still a number of different viewpoints and many people in the profession continued to search for the model for technology education. *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990) provided the technological method model and presented a conceptual model for technology education, as well as a series of suggestions for implementing the model in technology education programs.

Two years later, the Technical Foundation of America convened the Camelback Symposium "to allow selected leaders concerned about technology education to present their views on future directions for the field" (International Technology Education Association, 1992, Foreword). The primary outcome of the meeting was the publication of the *Critical Issues in Technology Education* document (International Technology Education Association, 1992). It served as a continuation of a discussion that began in 1947. As the final paper in the collection noted, nearly half a century of discussion still had not resulted in complete agreement on the subject.

TEXTBOOKS

The amount of professional reading done by secondary level technology teachers varies greatly from one teacher to another. While some are better read than others, virtually all technology teachers rely upon textbooks to assist with instructional delivery. For that reason, the evolving nature of texts in the field has had a significant impact on the delivery of technology education.

Davis Publications deserves credit for helping to usher in a new generation of textbooks for technology education. As a small publisher looking to expand its market in the 1970s, Davis approached Paul W. DeVore of West Virginia University. In the mid-1970s, Davis Publications and DeVore convened a group of professionals to discuss the development of a new series of technology education texts. DeVore envisioned a "bookshelf" of books on technology that would provide the content of technology, rather than focus on procedures, as did the industrial arts texts of the day. In 1978, Davis released the first of the series, *Technology, Change, and Society* (Pytlik, Lauda, & Johnson, 1978) and followed it with *Technology: An Introduction* (DeVore, 1980). Geared for the college level, these new books were unlike any college textbooks the field had seen before. They were *about* technology—its history, systems, impacts, and implications. Completely void of "how to" information, they were a radical departure from the norm.

Davis Publications soon followed with textbooks for the middle school and high school levels. These were the first texts to reflect the general content organizers: communication, production, and transportation. As with the earlier Davis Publications texts, they focused on the content of technology. When available, student activities and teacher workbooks were separate from the text, the latter intended more as reference than "how to" material. In 1991, Davis Publications left the technology education market, but their influence was evident in the books produced by other publishers in the field.

The industrial arts texts of the 1970s had been, for the most part, one or two-color books focusing heavily on procedures. The typical industrial arts textbook of the 1970s provided detailed procedures on a relatively limited number of industrial processes. For example, *Comprehensive Graphic Arts* (Dennis & Jenkins, 1974), a widely used book in graphic arts courses, described how to do layout and composition, copy preparation, process photography, letterpress, offset lithography, screen printing, continuous tone photography, and finishing/binding. These topics comprised more than 80% of the book, with less than 20% of the book describing other topics relating to the industry, such as paper manufacture and career opportunities.

In contrast, *Communication Technology: Today and Tomorrow* (Sanders, 1991) was a four-color publication from cover to cover, dealing mostly with process rather than procedure. The book was written for former graphic arts teachers who had broadened their courses to include five major content areas: graphic production systems (printing); data communication systems (computers); technical design systems (drafting/CAD); optic systems (photography, holography, etc.); and audio/video systems. The emphasis was on describing general processes or systems of communication rather than on specific procedures. In addition, it included sidebars on "Science Facts," "Technolinks," and "User's Guide to Technology," which provided additional content, rather than procedural information. The book was more a "how things work" than a "how to do" book, as was typical of industrial arts texts of the previous generation.

Not only did the books themselves change during this transition period, so too did the publishers. Several very prominent publishers, such as McKnight and Goodheart-Willcox, had enjoyed success by focusing all of their efforts on the field working relatively independently. Throughout the transition period, some traditional industrial arts publisher, such as Delmar and Goodheart-Willcox, seemed to maintain their independence, but others were acquired by larger publishing companies. McKnight, for example, was purchased by Glencoe and became a division of the much larger Macmillan/McGraw-Hill Publishing Company.

SUMMARY

The transition from industrial arts to technology education represents the most significant change in the history of the profession. There were a wide range of ideas, influences, and events that fueled the transition. The professional literature played a dual role: it opened up the dialogue to the entire profession and it documented the transition for future scholars to read and interpret.

During the 1980s, there were significant changes in the publications of the profession. Some, like *The Technology Teacher*, were proactive with respect to the changes taking place. Others, such as *SCHOOL SHOP* and *Industrial Education* aimed their sights on the vocational and technical audiences, while *The Journal of Epsilon Pi Tau* broadened its scope somewhat. The emergence of *TIES*, a magazine for those in the field seeking genuinely new ideas and the *Journal of Technology Education (JTE)*, the first research journal focusing specifically on technology education, were signs of the vitality of the profession. Moreover, the pioneering electronic publication of the *JTE* signaled a new era of tele-publication that will likely be at the forefront of all professional publication by the turn of the century.

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