this **ACIATE**/**CTTE yearbook** was scanned at the department of Technology and Engineering Education, Central Connecticut State University

…by Johnny Kassay and Pat Foster from the collections of several educators, including David Sianez and James DeLaura. **Responsibility for any copyright infringement is claimed by Patrick N. Foster**. We plan to improve this document by re-scanning, adding links, and/or direct neural input.

Essential Topics for Technology Educators

Editors

CTTE Yearbook Planning Committee

58th Yearbook

Council on Technology Teacher Education

2009

Essential Topics for Technology Educators

Editors

CTTE Yearbook Planning
Committee

58th Yearbook, 2009

Council on Technology Teacher Education

McGraw Hill Glencoe

McGraw Hill Glencoe

The McGraw-Hill Companies

Printed in the United States of America.

1 2 3 4 5 6 7 8 9 10 15 14 13 12 11 10 09

This publication is available in microfilm from:

UMI
300 North Zeeb Road
Dept. P.R.
Ann Arbor, MI 48106

FOREWORD

Over my two decades as a member of CTTE, I have been impressed (and often amazed) with the dedicated professionals and the activities linked to this association. Hard-working individuals have directed this Council as officers, with others serving on committees or chairing a task force. Hundreds of colleagues have contributed chapters to yearbooks. Still others have presented at conferences or prepared manuscripts for dissemination under the CTTE banner.

Nothing has been more important to the relevance or the positioning of the field of Technology Education as the efforts aligned with national content standards and a comprehensive assessment system for our profession. These initiatives have helped the discipline gain recognition, and placed us on a parallel footing with other subject areas.

Obviously, the primary curriculum standards work in Technology Education centered on the Technology for All Americans (TFAA) project. With the release of the STL standards in April 2000, members of this Council then developed teacher preparation program assessments linked to a universal group of content benchmarks. Today, ten unique standards define accredited technology teacher preparation institutions, with five standards related to "subject matter for technology education" and another five standards that address "effective teaching for technology education".

Therefore, during my professional career, I have seen this Council go from supporting an assortment of attractive topics to favoring a more focused series of themes under the Jackson's Mill umbrella to aligning programs, activities, and strategic initiatives to officially recognized benchmarks. What a transformation! Through collaboration with accreditation agencies and other groups, ten program standards are now the "glue" behind CTTE's plans and actions. Those same ten themes serve as the organizers in this publication.

When evaluating needed topics for future publications in early 2008, the CTTE Yearbook Planning Committee noticed that concepts related to all ten ITEA/CTTE program accreditation standards were not highlighted in any single yearbook. But a wealth of knowledge, insight, and theoretical discussions related to each of the principles already existed. It was found in the writings (in previous yearbooks) by legendary authors such as DeVore, Dugger, Sanders, Schwaller, Wright, et al. Ultimately, the committee identified a few of the significant contributions from earlier publications and included those chapters in this CTTE yearbook.

Hence the book you now have in your possession. It is called a "yearbook" because this is an annual publication, but terms such as "guide" and "textbook" might also apply. Naturally, I hope that today's CTTE members revisit the works of our mentors, those early Council leaders that influenced modern philosophy and actions. But I especially hope that future generations of technology educators also benefit from this special collection of chapters. I simply hope that household names from past generations might continue to shape the future of Technology Education.

Thanks to the efforts of the CTTE Yearbook Planning Committee and to the authors featured in this special publication. Also, a note of gratitude goes out to the Glencoe/McGraw-Hill Company for the continued support of the Councils' yearbook series. The nearly sixty year relationship is still strong, and technology educators around the globe benefit from these annual publications.

Richard D. Seymour
President, CTTE
March 2009

YEARBOOK PLANNING COMMITTEE

Chairperson

Michael A. De Miranda
Colorado State University

Terms Expiring in 2009

Kurt Helgeson
St. Cloud State University

Roger B. Hill
The University of Georgia

Terms Expiring in 2010

Mark Sanders
Virginia Polytechnic Institute and State University

William L. Havice
Clemson University

Terms Expiring in 2011

Phillip Reed
Old Dominion University

Brian McAlister
University of Wisconsin–Stout

Terms Expiring in 2012

Marie Hoepfl
Appalachian State University

Chris P. Merrill
Illinois State University

OFFICERS OF THE COUNCIL

President

Richard D. Seymour
Ball State University
Department of Technology
Muncie, IN 47306

Vice President

Chris Merrill
Illinois State University
Department of Technology
Normal, Illinois 61790-5100

Secretary

Philip A. Reed
Old Dominion University
Department of Occupational and Technical Studies
Norfolk, VA 23529

Treasurer

John G. Wells
Virginia Polytechnic Institute and State University
School of Education
Blacksburg, VA 24061

Past President

Michael A. De Miranda
Colorado State University
School of Education
Fort Collins, CO 80523-1584

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, which 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 first 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 major topics or issues related to technology teacher education 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 technology teacher education and to the field of technology education;
3. Not duplicate publishing activities of 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; and,
6. Lend itself to team authorship as opposed to sole authorship.

Proper yearbook themes related to technology teacher education may also be structured to:

1. Discuss and critique points of view that have gained a degree of acceptance by the profession;
2. Raise controversial questions in an effort to obtain a national hearing; and,
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 Committee to evaluate its merits.

2. The yearbook proposal includes the following components:

a) Defines and describes the topic of the yearbook;
b) Identifies the theme and describes the rationale for the theme;
c) Identifies the need for the yearbook and the potential audience or audiences;
d) Explains how the yearbook will advance the technology teacher education profession and technology education in general;
e) Diagrams symbolically the intent of the yearbook;
f) Provides an outline of the yearbook which includes:
i) A table of contents;
ii) A brief description of the content or purpose of each chapter;
iii) At least a three level outline for each chapter;
iv) Identification of chapter authors and backup authors;
v) An estimated number of pages for each yearbook chapter; and,
vi) An estimated number of pages for the yearbook (not to exceed 250 pages).
g) Provides a timeline for completing the yearbook.

It is understood that each author of a yearbook chapter will sign a CTTE Editor/Author Agreement and comply with the Agreement. Additional information on yearbook proposals is found on the CTTE Web site at http://teched.vt.edu/ctte/.

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. Richard D. Seymour and Ray L. Shackelford, eds.
***43.** *Construction in Technology Education,* 1994. Jack W. Wescott and Richard M. Henak, eds.
***44.** *Foundations of Technology Education,* 1995. G. Eugene Martin, ed.
***45.** *Technology and the Quality of Life,* 1996. Rodney L. Custer and A. Emerson Wiens, eds.
46. *Elementary School Technology Education,* 1997. James J. Kirkwood and Patrick N. Foster, eds.
47. *Diversity in Technology Education,* 1998. Betty L. Rider, ed.
48. *Advancing Professionalism in Technology Education,* 1999. Anthony F. Gilberti and David L. Rouch, eds.
***49.** *Technology Education for the 21st Century: A Collection of Essays,* 2000. G. Eugene Martin, ed.
***50.** *Appropriate Technology for Sustainable Living,* 2001, Robert C. Wicklein.
51. *Standards for Technological Literacy: The Role of Teacher Education,* 2002. John M. Ritz, William E. Dugger, and Everett N. Israel, eds.
52. *Selecting Instructional Strategies for Technology Education,* 2003. Kurt R. Helgeson and Anthony E. Schwaller, eds.
53. *Ethics for Citizenship in a Technological World,* 2004. Roger B. Hill, ed.
54. *Distance and Distributed Learning Environments: Perspectives and Strategies,* 2005. William L. Havice and Pamela A. Havice, eds.
55. *International Technology Teacher Education,* 2006. P. John Williams, ed.
56. *Assessment of Technology Education,* 2007. Marie C. Hoepfl and Michael R. Lindstrom, eds.
57. *Engineering and Technology Education,* 2008. Rodney L. Custer and Thomas L. Erekson, eds.

*Out-of-print yearbooks can be obtained in microfilm and photocopy forms. For information on price and delivery, write to: UMI, 300 North Zeeb Road, Dept. P.R., Ann Arbor, Michigan 48106.

PREFACE

The ITEA/CTTE program standards were rewritten by the CTTE Accreditation Committee and finalized in October of 2003. The following curriculum standards have been reviewed extensively by the technology teacher education profession over the past several years. The ITEA/CTTE program standards are a result of several projects including:

1. The Professional Development Standards, part of International Technology Education Associations' Technology for All Americans Project (2003).
2. The 1997 ITEA/CTTE/NCATE guidelines approved by NCATE.
3. The INTASC Standards.
4. The Standards for Technological Literacy, part of International Technology Education Associations' Technology for All Americans Project.
5. The suggested format for standards conforming to national accreditation using knowledge, performance, and disposition indicators.

There are ten standards addressed in this yearbook. The ten standards are subdivided into two sets as shown below:

Subject Matter Standards for Technology Education

Standard 1 — The Nature of Technology
Standard 2 — Technology and Society
Standard 3 — Design
Standard 4 — Abilities for a Technological World
Standard 5 — The Designed World

Effective Teaching Standards for Technology Education

Standard 6 — Curriculum
Standard 7 — Instructional Strategies
Standard 8 — Learning Environment
Standard 9 — Students
Standard 10—Professional Growth

Standards and sections 1–5 in this yearbook specifically focus on the subject matter of technology. For more detailed descriptions of standards 1–5, refer to the *Standards for Technological Literacy: Content for the Study of Technology,* (ITEA, 2000).

Standards and sections 6–10 identify the knowledge necessary for effective teaching of technology in technology teacher education programs. For more detailed descriptions of standards 6–10 refer to the *Professional Development Standards* (ITEA 2003). Both of these documents are part of the Technology for All Americans Project.

We hope that this yearbook volume will provide a solid foundation for promoting enduring understandings of quality program indicators and the knowledge base for preparing technology education teachers.

58th Yearbook Editors
CTTE Yearbook Planning Committee

ACKNOWLEDGMENTS

The CTTE Yearbook Planning Committee would like to thank our friends at Glencoe/McGraw-Hill for their ongoing commitment to Technology Education through the CTTE Yearbook series. The yearbooks serve to document the key issues in our profession today and provide a valuable resource in establishing and communicating a future direction.

Appreciation must be expressed to each member of the Yearbook Planning Committee for their guidance and support in bringing this volume to life. The expertise and commitment of these individuals sustains a long tradition of professionalism that dates back to the inception of the series.

Finally, we particularly want to thank the authors assembled in this volume for their scholarly contribution. In order to honor the integrity of the authors' original manuscripts in this volume, the APA publication style in effect at the time of original publication has been preserved. The yearbook planning committee genuinely respects and thanks all contributors for their insights and professionalism.

TABLE OF CONTENTS

Section IX: Students

Section X: Professional Growth

xiv

INTRODUCTION

National program standards serve what purpose? Good question, let's see if I can provide an answer or just stimulate your thinking on this topic. Engineering, medicine, architecture, law, social work, and physical therapy professions answered this question years ago when they established nationally accredited program standards. Today, no worthy professional in these disciplines would ever seek to graduate from a program that was not nationally accredited. Would you seek the services of a medical doctor, engineer, or lawyer who had not graduated from an accredited program? I suspect your response would be a resounding NO. Then, why would we expect a parent to allow their child to enter a classroom when the teacher is not a graduate of a nationally recognized program?

This yearbook explores the value of accreditation, national recognition, and national program standards. The Yearbook Committee, through the chapters presented in this yearbook, underscore why ITEA/CTTE joined 19 other professional associations in developing national program standards. Today, ITEA/CTTE program standards embody the consensus of our field on the knowledge, skills, and professional dispositions our teachers should possess. When a technology teacher preparation program receives national recognition from ITEA/CTTE, it communicates to all other academic units on its campus, and in its state, and in the nation that it has achieved something truly special.

Program standards give ITEA/CTTE academic credibility with other professional associations including the National Council of Teachers of Mathematics and National Science Teachers Association. National program standards allow ITEA/CTTE to be represented as an equal partner in national accreditation meetings and to enter into constructive dialogue with representatives of other associations. When a profession has national program standards, it opens doors of opportunity at all levels that otherwise would not be accessible.

The presence of well developed and articulated program standards communicates to the broader education community that ITEA/CTTE recognizes the importance of having high quality teacher education preparation programs. ITEA/CTTE's program standards allow technology teacher education program faculty to benchmark their programs against national standards of quality. And, when a technology teacher education program is awarded national recognition, it represents the achievement of the highest standards of quality in technology teacher preparation.

The publication, *What Makes an Effective Teacher?* summarizes the results of several national research studies in teacher preparation. One conclusion is that "research supports the idea that high quality teacher preparation is important…well prepared teachers outperform those who are not prepared." ITEA/CTTE's program standards help ensure high quality in our technology teacher preparation programs and help ensure our newly prepared teachers are more than ready to enter the classroom. Programs of quality and well prepared graduates…that is the purpose of national program standards.

Gene Martin, Professor
Texas State University—San Marcos

The Nature Of Technology

Section I

STANDARD 1—THE NATURE OF TECHNOLOGY
Technology teacher education program candidates develop an understanding of the nature of technology within the context of *the Designed World.*
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 1. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Explain the characteristics and scope of technology. • Compare the relationship among technologies and the connections between technology and other disciplines.
Performance Indicators:
• Apply the concepts and principles of technology when teaching technology in the classroom and laboratory.
Disposition Indicators:
• Comprehend the nature of technology in a way that demonstrates sensitivity to the positive and negative aspects of technology in our world.

Technology and Science

Chapter 1

Paul W. DeVore
36th CTTE Yearbook, 1987

Sub-Topics:

- **Exploring the Differences Between Technology and Science**
- **Alternative Views of Technology**
- **Intellectual Factors of Technology**
- **Knowledge and Technology**
- **The Relationship Between Scientific and Technological Development**
- **Technology and Science**
- **Summary**

It is not possible to address the topic of technical research without being confronted with the long-standing debate on the relationship between technology and science. Much has been written on the topic ranging from attempts to obtain political and economic gain for "pure" science in the public arena to interest in metaphysical issues.

The issue is critical for those confronted with decisions concerning the allocation of resources for research whether for business, industry or government. Proponents of research in pure science perpetuate the myth that all technical advances follow scientific discoveries, even though a number of well designed studies conducted in the United States and England have documented the fallacy of this belief.

Confusion also exists in numerous standard reference publications and general use textbooks. In a typical publication it is generally stated that science began thousands of years before man learned to write. This "science" is described as the discovery of fire, the invention of the wheel, the wheel and axle and the bow and arrow. Further evidence in support of science is presented by noting that Europe could not have exploited vast continents without railroads, canals, steamships and weapons. In most histories of technology the developments cited would be listed as tech-

---

NOTE: Portions of this chapter are from DeVore, Paul W. *Technology: An Introduction,* Davis Publications, Inc., 1980.

nological developments, not scientific. There was little or no connection between the science and the technical developments of the eras cited.

The confusion is enhanced by the gross personification of the terms science and technology with statements like: Science does *thus and so,* or Technology does *this or that*. This personification of large complex fields of human endeavor obscures the true nature of the actual behavior in these fields.

What has been taking place over the last several centuries is an evolution in ways of thinking and relating to the world. This change began in the sixteenth century with discoveries about the natural world including Nicholaus Copernicus' heliocentric theory, Newton's contribution to gravitational theory and the calculus, Priestley's isolation of oxygen, Mendel's contributions to the field of genetics, Pasteur's germ theory of disease and Darwin's theory of evolution.

Concurrent with these contributions were major changes in the technical means of production, communication and transportation. Among the developments were: the three field system of agriculture, farming machinery, the lathe, spinning wheel, mechanical clock, surveying instruments, navigation instruments, atmospheric sensing devices, optical devices and precision instrument development. Other developments were the dividing engine by Jesse Ramsden, and the surface plate, bench micrometer, screw gauge, end measurement and plug and ring gauge by Joseph Whitworth.

The contributions of John Kays, Lewis Paul, John Wyatt, James Hargraves, Richard Arkwright, Samuel Crompton and Edward Cartwright in the design and development of the means for the mechanization of the textile industry were significant in the early part of the eighteenth century.

People like Charles Plumier, Jacques Besson, Jacques de Vaucanson, Henry Maudslay, David Wilkinson, John Wilkinson, James Nasmyth, Richard Roberts, Joseph Clement and James Fox created the machine tool base for the industrialization of the Western world. Equally significant were the contributions of Vannoccio Biringuccio, George Bauer and Rene Antoine de Reaumur to knowledge of the physical properties of iron.

The technical means to greatly increase the amount and quality of iron and steel rested on the contributions of Abraham Darby I (use of coke to smelt iron), Henry Cort (the puddling furnace and grooved rolling mill), Christopher Polhern (improved rolling mill), Henry Bessemer (iron to steel process), Percy Gilchrist and S. G. Thomas (improved the Bessemer process) and the Siemens and Martin brothers (open hearth process).

Chemical industries were developed through the work of Joshua Ward, Karl Scheele, Charles Tennant, Charles Macintosh, Nicolas LeBlanc, James Muspratt, Ernest Solvay, Henry Perkins, Charles Martin Hall and Paul Louis Toussaint.

The means of energy conversion were improved during this era by people such as Olaus Magnus (overshot waterwheel), Lester Pelton (water turbine), Thomas Newcomen (atmospheric steam engine), James Watt (separate condenser and double acting steam engine), Gustav de Laval and Charles Parsons (steam turbine), Otto von Guericke (static electricity), Alessandro Volta (battery), Hans Christian Oersted (electricity and magnetism relation), Andre Marie Ampere (quantification of electricity-magnetism relation), Michael Faraday (production of electricity from magnetic effect), Z. T. Gramme (ring armature), Joseph Henry (D. C. electric motor), Nikola Tesla (A.C. electric motor), Nicolaus Otto (four-stroke cycle internal combustion engine) and Rudolf Diesel (compression ignition engine). Even though all the individuals listed above have contributed to the development of the technical means of energy conversion, the pure scientists would be readily identified in any name recognition game.

What has been occurring is the evolution of a new discipline, technology, which is neither dependent upon nor subservient to science, as commonly known and perceived. *Technology is one of the new sciences.* The intellectual endeavors involved in the creation of the technical means of today are of a different order from those of the craft era of the past. The modes of thinking have established the base for the new disciplines and the new science, technology. Those involved in this new science are concerned with the behavior of tools, machines and technical systems. They base their work on information about the behavior of multiple variables and dynamic environments. Common outcomes or traits of the new science (technology) are predictability, replication, reliability, optimization and efficiency of system operations based on theoretical models. Rules and systematic predetermined procedures are based on objective knowledge. Emphasis is on logical, instrumental, orderly and disciplined approaches. This view is supported by most recent investigations that conclude that technology and science, as commonly perceived, are distinctly different forms of human behavior. The concept of technology and science being at different ends of the same continuum is probably false. What is probably true is (1) that technology is one of the sciences, as are biology, psychology, sociology and other disciplines concerned with human behavior, and (2) that the source of the problem is the term science as it is commonly used. Even if the problem is explored using the commonly accepted definitions of science and technology, we find two distinctly different forms of activity with different goals, questions and means. Each field is mutually exclusive and not mutually dependent, although as with all sciences, each has been enhanced by the other.

EXPLORING THE DIFFERENCES BETWEEN TECHNOLOGY AND SCIENCE

Even if the differences and relationships between technology and science are explored from commonly held perceptions, it is evident that adjustments in these perceptions are in order.

Most writers conclude that there are differences between technology and science, and attempt to show relationships with few definitive conclusions. This stems from at least two factors: (1) the background, experience and value context of the writer and (2) the changing nature of both technology and science. Many writers discuss differences or relationships based on seventeenth or eighteenth-century technology and science, and then project their findings to the twentieth century. These writers seem to exhibit a decided pro science perspective by suggesting that technological advance came only from the practical application of scientific discovery.

However, as other investigators have shown, the linkages between events in technology and science have not been proved. According to Lynn White, "until the middle of the nineteenth century there were remarkably few connections between science and technology", (p. 161). White maintains that technology has had a greater influence on science than science on technology.

Technology and science have different antecedents. Technology has always been situated directly in the social milieu and conditioned by values, attitudes and economic factors. The latter is evident in the research by Schmookler, who investigated whether (1) important inventions are typically induced by scientific discoveries, and whether (2) inventions are typically induced by intellectual stimuli provided by earlier inventions (pp. 57–58).

Schmookler and his colleagues compiled chronologies of important inventions in four industries: petroleum refining, papermaking, railroading and farming. He noted that although none of these industries owed their origin to scientific discoveries, the petroleum and papermaking industries have had relationships with science similar to the electrical, plastics, nuclear and electronic industries. He concluded the hypothesis that scientific discoveries direct the course of invention, if true, would have a fair chance of surviving the test.

Two types of inventions that were included in the study: (1) inventions that were *economically important* in their effect on the industry and (2) inventions that were *technologically* important in providing a base for subsequent innovations which were economically significant. Nine hundred and thirty-four inventions were identified using these criteria for the period 1800 to 1957 with 235 of the inventions in agriculture, 284 in petroleum refining, 185 in papermaking and 230 in railroading.

It was found that few of the inventions were directly stimulated by specific scientific discoveries, although each field had inventions which did depend on other fields of science. Decisions on whether to invent or to develop an invention for commercial use were not automatic outgrowths of scientific discovery; rather, they depended on value judgments made in the "context of the times."

The investigators also established that scientific discovery is seldom a *sufficient* condition for invention, either in the short or the long run, and that particular scientific discoveries are seldom even *necessary* conditions for later inventions (Schmookler, pp. 70-71). It seems as though technological progress cannot be predicted from the progress of science even though science opens up a variety of alternative paths for invention and technological development. Choice of the path of development depends largely on extrascientific factors. In general, Schmookler's study supports Schrier's contention that "not all technology is scientifically based, nor is all scientific research directly applicable to technology", (p. 345).

The attempt to build a case by looking backward and placing a higher value on contemplation than on action has delayed the probability of gaining true insight into the nature of the differences. If a true perception of technology or science is to be attained at a given time in history, it is necessary to structure the perspective from that era, not the present. Why? Because there has been a continual evolution in the meaning of the words technology and science.

Differentiating between technology and science today is best accomplished, according to Otto Mayr, by focusing discussions on several categories. They include (1) the nature of the knowledge structure, (2) the type of work and activities engaged in by the people who do the work, (3) the motivation (ideologies) of the people who engage in technology or science and (4) the aims and goals toward which the activities are directed (Mayr, pp. 667–669).

None of the criteria will differentiate if used singly. The problems of differentiation between technology and science are too complex to rely on single variables. It may be that a clear, concise differentiation will never be attained unless current evidence is entertained and alternative approaches to the problem are entertained.

ALTERNATIVE VIEWS OF TECHNOLOGY

In most writings on technology, the nature of technology is discussed and also is the issue of knowledge and technology. There are numerous views expressed, all of which are based on a philosophical orientation. The philosophical orientation may be derived from two perspectives according to Skolimowski: a *philosophy of technology* or a *technological philosophy*. Those involved in the philosophy of technology are concerned with the questions of knowledge and technology, whereas those concerned about technological philosophy are involved in value questions relating to the social use and the future of human beings and society (1966).

The issue of whether technology is based on *knowledge* or *knowing* or *know-how* and *doing* is a relatively new question. Layton believes the separation of knowledge and technology is both recent, artificial and contradictory:

> Technique means detailed procedures and skill and their application. But complex procedures can only come into being through knowledge. Skill is the "ability to use one's knowledge effectively." A common synonym for technology is "know-how." But how can there be know-how without knowledge? (1974, p. 33).

The focus of Layton's view is on knowledge about the behavior of technical elements and systems.

In discussing knowledge and technology, many people equate the attainments in technology with prior work in science. This implies that science is the knowledge base for technology. Scholars such as Skolimowski and others state emphatically that technology is not science, nor is technology dependent on science. Skolimowski maintains that "the basic methodological factors that account for the growth of science" (1966). He believes that technology is a form of human knowledge and that the idea of technology can be best understood by focusing on the idea of technological progress.

This suggestion is compatible with those who have studied the differences between past and present technology. Bell (p. 174) notes that there are major dissimilarities between the present and the past and cites "the nature of technology and the way it has transformed social relationships and our way of looking at the world" as the basic reason for these differences. It has been recognized that the modes of thinking, doing and acting associated with technological endeavors create new realities. As Skolimowski reminds us, "Science concerns itself with *what is,* technology with *what is to be.*"

The creation of new realities and extending the boundaries of the possible requires a know-how based on knowledge. The question which bothers traditionalists is what kind of knowledge is technological knowledge?

Jarvie believes technological knowledge is that knowledge which is part of humankind's "multiform attempts to adapt to the environment." Perceived in this fashion, technological knowledge is knowledge generated through thinking and action involved in creating adaptive systems as opposed to knowledge used to create ideological and/or social systems.

Jarvie's distinction between what he describes as two senses of the word "know" assists in clarifying types of knowledge. One form of knowing is "know-how." One can *know how* to create a design, build a machine, analyze traffic flow or develop a new communication system. One can *know* that designers exist or traffic flow is analyzed before a new system is proposed, or that the geographical limits of efficient government are a function of the speed and efficiency of communications. Whereas past technical means might have been created largely by "know-how," today is not only "know-how" and "know-why."

Jarvie proposes that the concept of tools must be expanded to include "knowing-that" side of knowledge. During early technological development, tools were largely extensions of the physical elements of human beings. Today, formulas and procedures are tools. A computer program is a tool as are procedures used to collect data for technological forecasting. Changes in tools have changed the character of our technical means and in the process, the structure of technological knowledge (Jarvie, 1967).

The character of the knowledge required to maintain life in a primitive preagricultural society is greatly different from today's highly complex technological societies. Primitive societies evolved slowly as did their technical means. Prior to eighteenth century, technical work was purely pragmatic, inquiry was empirical and diffusion was slow. It was relatively easy for people to keep abreast of their technical means and control its use and influence.

According to Bunge, technology crossed an important threshold in the eighteenth century and became self-sustaining. This resulted from the establishment of rules for technology. Previously technology was controlled by *conventional rules* which were adopted with no particular reason. Conventional rules were culture-centered rather than technology-centered and consisted of rules such as tipping one's hat or striking the anvil twice before striking the metal (Bunge, p. 339).

The establishment of technology-centered *ground rules* based upon a set of formulas capable of measuring effectiveness changed the nature of technology. Effectiveness could no longer be accepted from observation and consensus. It was now necessary to *know why*. The formulation of the rules that control the productive process was the beginning of the rationalization to technology. Perhaps it was also a return to the original meaning of *technologia,* the giving of rules to the arts (Buchanan, p. 157). Today, the primary characteristic that is evolving is the centrality of theory over empiricism.

The new theoretical knowledge is a source of invention and innovation and is the base for a new intellectual technology: a technology based more on intellectual and analytical processes than on mechanical, manipulative or physical processes. According to Daniel Bell, the new intellectual technology consists of "such varied techniques as linear programming, systems analysis, information theory, decision theory, games and simulation. When linked to the computer, they allow us to accumulate and manipulate large aggregated of data……to have more complete knowledge of social and economic matters" (pp. 157–158).

In most discussions of knowledge and technology, a common descriptor is used: application. Drucker makes the case that knowledge is not at the cutting edge, technology is. Knowledge exists only insofar as it is applied to do something. Up to that point it is only information.

Technologists are concerned with the knowledge of application and application of knowledge. One must know in order to do. This is true regardless of what stage of technological development is being analyzed. Knowledge of application is necessary to achieve any survival success. Survival potential increases as new information about the environment is obtained, tested, applied and refined to become the new knowledge base.

INTELLECTUAL FACTORS OF TECHNOLOGY

Another factor becomes evident in examining the nature of knowledge and technology. The character of thinking involved in creating a philosophical position, a new religion or an alternate form of government is different from the character of thinking involved in technological activities. Thinking in technology is problem and environmentally specific. It is concerned with efficiency and the relationship of elements in the *behavior of sub-systems and total systems.* The question of behavior engages the question of "why" one system is more effective than another as well as "how" the system works. The goal is predictability of outcome and performance.

Technological knowledge is more than knowing about such things as tools and machines. Jarvie points out that technological knowledge would have no place in the structure of knowledge it technology were only tools, what an inventor invents or what applied scientists do to show what a theory explains (1967, p. 9). To Jarvie and others, technological "knowing" must involve certain intellectual processes to be considered knowledge.

Layton analyzed the issue in some detail in his article, "Technology as Knowledge" (p. 39). He suggested that the common denominator is the "ability to design" which connotes an "adaptation of *means* to some preconceived end." Layton believes this is the central purpose of technology.

This point of view relates well with other characteristics such as being problem-oriented and problem- and environmentally- specific. It also emphasizes a characteristic that makes technological knowledge unique: the ability to combine many diverse factors and elements into a working whole in order to reach some preconceived end. It is necessary to "know" the way things function and to be able to analyze the relationships and synthesize new relationships, to create new inventions, innovations of designs. The nature of the thought processes in this hierarchy of thinking is unique and central to the generation of technological knowledge.

KNOWLEDGE AND TECHNOLOGY

Knowledge in technology is (1) *knowing that* something is true in a given context and (2) *knowing how* to accomplish a preconceived end. Creativity in the technologies combines the *universe of knowing* with the *universe of doing*. It is a unique intellectual enterprise.

Layton views technology as a spectrum, with ideas at one end, techniques and things at the other. The design process is in the middle. Ordinarily, most analyses of knowledge and technology focus only on things and techniques. By doing so, they omit the entire intellectual component of technology. The origin of things and process which brings things into being is with human intellect, not in the things.

It is also important to recognize that whereas science, as commonly perceived, is concerned primarily with *what is* and nature and structure of the physical universe, technology is concerned with *what can be.* In determining "What can be?", values and the process of valuing become paramount. Therefore, rather than focusing on discrete elements, those involved in the creation of technical means must be concerned with totalities, with systems and the behavior of systems. It is here that the greatest difference exists between science and technology. Whereas those involved in other sciences are concerned with nature, technology is concerned with human beings, the physical world and society. It is one thing to determine the nature of physical phenomenon. It is quite a different thing to collect and analyze data related to a specific problem, create and test a design and implement the proposed solution in a human context. This is a new way of thinking. A new science which is the base for technical research.

THE RELATIONSHIP BETWEEN SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT

The literary scene has been dominated by those with a humanist tradition. Traditionally, humanists have shown a widespread disregard for technology's role in human affairs (Smith, p. 493). The same has been true of historians who have been more concerned with "great movements headed by kings, generals or businessmen." When they wrote about the events of technology and science, they emphasized that with which they were most familiar, traditional science and philosophical ideas. To the traditional humanist and historian, technology was merely the application of scientific laws and theories.

The importance of science and scientific ideas cannot be denied. They have had a great impact on our perception of ourselves and our universe. The problem has been the ignorance or indifference toward the importance of technology. As Smith reminds us: "Anyone who considers the nature of materials, advocates a new way of making pottery or advances a new theory of the hardening of steel meets with both intellectual and popular indifference" (p. 494). Importance has been assigned to contemplation rather than to action.

Yet in the world of reality, the world beyond traditional historical inquiry, there had been a uniting of "knowing" and "doing." Technology has become linked with social purpose. The goal has become the pursuit of knowledge and know-how for specific social ends. The range of technological activity today includes everything from problem identification to the design and implementation of solutions. This involves not only technical or physical elements but human elements as well.

Even so, many individuals exploring the relationship between technology and science restrict technology to invention or the application of a scientific theory or law to a specific technical device. By doing so, they restrict not only the true meaning of technology but that of science as well.

A more accurate relationship is presented by people like Rabi, who noted that in earlier civilizations technological progress was made without science; that there were developments in metals and development in textiles, building and construction, transportation, mining, agriculture, forestry, food preservation, energy conversion and power development. The belief that science creates new knowledge which technologist then apply is stated so often that it has been accepted as true.

This belief was so prevalent that the U.S. Department of Defense funded Project Hindsight to determine what key events made possible the development of 20 weapons systems. Seven hundred key events were studied to determine whether they were technological or scientific. Over 99 percent of the events were found to be technological events. Only 0.3 percent of the events were found to result from basic science. The results were startling and contrary to commonly held views.

Another study, conducted by the Illinois Institute of Technology Research Institute in 1968, *Technology in Retrospect and Critical Events in Science* or TRACES* (1968), illustrated that a relationship between science and technology did exist, but not in a direct linear form. It was discovered that technology or mission-oriented research and development efforts brought about nonmission or basic science research which later influenced a given innovation (Layton, 1971).

---

*The TRACES project documented the events that were considered to be crucial in leading to five innovations: magnetic ferrites, videotape recorder, oral contraceptive pill, electron microscope and matrix isolation.

A follow-up study by Battelle Columbus Laboratories (Battelle, 1973) supported the findings of the TRACES research. The Battelle study, which focused on the identification of key influences on *decisive events* (an occurrence that provides a major and essential impetus to an innovation—without this event the innovation would not have occurred) in the innovation process, found that:

1. The recognition of technical opportunity ranged from moderately to highly important for 87 percent of the decisive events, indicating that the opportunity to create an improved product or process is a strong motivating force in the innovative process.
2. The recognition of consumer need or demand ranked second in importance and was judged important in 69 percent of the decisive events.
3. The technical entrepreneur (individual within the performing organization who champions a scientific or technical activity—a product champion) ranked as important in 56 percent of the events. (Battelle, p. 3–1).

The technical entrepreneur was identified as a "characteristic" that was important in nine of the ten innovations studied as a whole and was also a "factor" of significance with respect to individual decisive events. The fact that the technical entrepreneur is a significant driving force in the innovative process as identified in the Battelle study is important to note when the concern is with enhancing the technical research process.

Another factor which differentiates technological from "scientific" activities is the role "unplanned" confluences of technical events play in innovation. In the Battelle study this was a factor in six of the ten innovations. It was found that in all cases additional supporting innovations were required in order to refine and improve the original concept and allow the ultimate product or process to reach the market place (Battelle, p. 3–2).

These and other studies support Layton's conclusion that the problem in discussing the technology-science relationship is the assumption that science and technology represent different functions performed by the same community. Science and technology represent different communities, each with different goals, sets of values, social controls and reward systems. The result is that science begets more science and technology more technology. Gibbons and Johnson found that science acts in a supporting rather than an initiating role (Langrish, p. 9). Their study showed that there is a relationship, but the importance of science to the creation and development of technical means has been exaggerated. Kranzberg attributes this exaggeration to "chronological fallacy," which is the belief that because one event preceded another chronologically the events were connected causally. The most common connections used to show the relationships between prior science and later technology are the development of the steam engine and the transistor. The 1500-year period from Heron's experiments with expanding steam to James Watts' improvement of Newcomen's atmospheric steam engine and the development of the transistor in the late 1940s are often cited to illustrate the decreasing period of time from scientific discovery to technological development. The problem with the comparisons is that the development of the steam engine did not begin with Heron, but with Newcomen and his predecessors, and that the steam engine was a technological development, not a scientific one. The development of the steam engine came about because of a problem with mine drainage. Historians such as Kranzberg conclude that "new technology grows mostly out of old technology, not out of science," and "scientists concern themselves chiefly with the problems posed by science, not by technology" (Kranzberg, p. 27).

J. M. Langrish and others also question the chronology methodology (p. 35). They offer four reasons:

1. Difficulty in defining the scientific discovery on which a technological application is based. Different time intervals are assigned by different authors for given innovations.
2. Possible biases in selection of innovations and events due to absence of standard selection procedures. "It is in fact not difficult to produce sets of example which show time-lags *increasing* substantially during the last hundred years or so."
3. Impossibility of observing anything other than a short time-lag for recent discoveries. "Discoveries made in the last few years may be exploited in the future, and such cases are of necessity excluded from consideration."
4. Many cases have negative time-lags. Many times technological advance comes *before* the scientific advances that help to make them understandable such as was the case with the first synthetic rubber and plastics which were produced prior to the development of polymer chemistry.

TECHNOLOGY AND SCIENCE

There are relationships between technology and science, but of a different order than commonly believed. According to Kranzberg, the relationship between technology and science can be best described as a disunity rather than a unity, and as *two distinct orders of activity* engaged in by human beings with an ongoing dialectic between them (1968, p. 30). Relationships are more dependent on the situation or problem than on doctrine. The relationships, according to Kranzberg, are pragmatic, free of formal protocol and exist in specific contexts which vary according to the situation (1968, pp. 32–33). Rather than one relationship there are many, with the initial entree and dialectic determined by the situation and the problem.

The difference between technology and science is distinct, particularly with reference to goals, nature of the problem and problem setting.

Technology	Science
Goal: to create the human capacity to do; to create new and useful products, devices, machines, or systems.	*Goal:* to obtain fundamental understanding of nature and the physical universe.
Problem: complex and interrelated problems involving design, materials, energy, information and control. Many variables, both technical and social. Involves total system design.	*Problem:* small, highly detailed, manageable problems designed to contribute to a body of information that may provide the base for generalizable theories.
Setting: situated directly in the social milieu.	*Setting:* isolated from requirements of meeting direct social needs.

One way to clarify the technology and science issue is to investigate the *goal*s and *scope* of inquiry of each discipline and the critical variables for distinguishing between and among various human intellectual endeavors (Gruender, pp. 456–57).

Goals: The goals of the discipline concern the purposes of the activity while scope concerns the narrowness or breadth of the activity. If the goal of an activity is set by some specific human problem, the nature of the activity is technological. Whereas, if the goal of the activity is based on curiosity and interest in finding basic generalizable theories, the activity is scientific. Bunge (p. 68) believes that just as pure science focuses on objective patterns or laws, action-oriented research aims at establishing stable norms of successful human behavior: that is, rules. By rule, Bunge means a prescribed course of action to achieve a predetermined goal. However, caution should be exercised in making too simplistic a separation. Abstract theories can be used for the solution of practical problems and the solution of practical problems often leads to abstract theories.

Scope: Scope is generally established by the goal, aim or purpose of the problem, inquiry or activity. If the scope of the problem is clearly defined as solving a human or social problem within a specified environment, then the activity is technological. If the *goal* of the problem, inquiry or activity does not restrict the *scope* of the results sought or the direction of inquiry, then the activity is another form of scientific endeavor.

The creation of technical means is situated in a human and social context from which the *goals* that direct the activities of the discipline are derived and the *scope* of the field of inquiry is determined. In the process of development, the goals and scope of the discipline of technology are altered as new potential presents new choices. Today, rather than focusing on problems concerned with specific tools for a specific application in a given craft within a limited social environment, the goals and scope of technological problems include inquiry into total systems and their interrelatedness, technically and socially.

In the traditional view, science would be different. In the pure sciences, it is essential that the human element be eliminated, and the variability of human responses be controlled (Ashby, p. 82). The goal of science is to seek explanation for the behavior of the natural world, not to solve problems related to creating adaptive means to aid humans to live in the natural world. However, Anna J. Harrison has proposed that science is the *process of investigation** of physical, biological, behavioral, social, economic and political phenomena. Harrison uses process in a collective sense, encompassing everything the investigator does from the selection of the phenomena to be investigated, to the assessment of the validity of the results. The outcome is scientific knowledge. Technology is perceived to be the *process of production** and the delivery of goods and services. Technological innovation is the *process of investigating** how to more effectively produce and deliver goods or services, modify significantly their characteristics or create and deliver new goods or services. The outcome is technological knowledge consisting of a data base with an array of concepts (p. 1242). Ziman notes a corpus of generally accepted principles has developed in every technical field. Modern technology is definitely scientific because there is continuous formal study and empirical investigation of the aspects of technique (Michalos, p. 24).

---

*Italics added by author.

SUMMARY

Individual perceptions of various topics of phenomena are largely dependent on a person's background, the amount of study and reflection given to the topic and personal experiences with the phenomena. This is certainly true of the technology-science issue. With respect to technology, viewpoints about its nature range all the way from technology as a tool, to technology as a major component of the adaptive systems of civilization. It is thought of as skill, craftsmanship, artifacts, technique, work or a system of work, engineering, a body of knowledge, a discipline, a system of means, an effect and other similar constructs. Similar viewpoints exist with respect to science. Each viewpoint differs depending on the perception of the individual espousing that viewpoint.

The many diverse viewpoints are of little help to those concerned with establishing public or corporate policy with respect to industrial or technological research. If there are no common agreements about perceptions or meaning, it is not possible to develop an appropriate and successful research agenda with *goal* of maintaining technological prominence and contributing to the improvement of human existence. Nor is it possible to establish programs of assessment to determine future directions for the allocation of resources for research for given goals. This is a primary and continuous problem facing leaders in business and industry.

There is a growing recognition that the character and nature of today's technology is more theoretically, intellectually and systematically derived. Those involved in the various fields of endeavor in the technologies are systematically pursuing the search for knowledge and understanding of the behavior of various technical systems concerned with the transformation of materials to useful products. This involves the transmission, reception, storage and retrieval of information and the efficient movement of goods and services. These human activities are associated with other branches of knowledge and know-how that have also been systematically derived.

The discipline of technology is the *systematic study* of the creation, utilization and behavior of adaptive systems. It includes the tools, machines, materials, techniques and technical means along with the behavior of these elements and systems in relation to human beings, society and the environment.

The question *is not one* of differentiating between technology and other sciences. The question is to determine the most appropriate direction for improving the creation and application of new technological knowledge through well designed technical research and development programs.

REFERENCES

Agassi, Joseph. "The Confusion Between Science and Technology in the Standard Philosophies of Science." *Technology and Culture,* Vol. VII, No. 3., Summer 1966.

Ashby, Eric. *Technology and the Academics.* New York: St. Martin's Press, Inc., 1963.

Atkinson, Richard C. "Education for an Age of *Science.*" Science, March 30, 1984.

Battelle Columbus Laboratories. "Interactions of Science and Technology in the Innovative Process: Some Case Studies." Springfield, Virginia: National Technical Information Service, U.S. Department of Commerce, 1973, p. 218.

Bell, Daniel. *The Coming of Post-Industrial Society.* New York: Basic Books Publishers, Inc. 1973.

Buchanan, Scott. "Technology as a System of Exploitation." *The Technological Order*, Detroit: Wayne State University Press, 1963.

Bunge, Mario "Towards a Philosophy of Technology." ed. Alex C, Michalos. *Philosophical Problems of Science and Technology,* Boston: Allyn and Bacon, 1974, pp. 28–47.

Bush, Vannevar. Science—The Endless Frontier. Report to President Harry Truman, 1945. Reprinted May 1980, Washington, DC.: National Science Foundation.

Cardwell, D.S.L. *Turning Points in Western Technology.* New York Neale Watson Academic Publications , Inc., 1972.

Cassidy, Harold G. Knowledge, *Experience and Action*. New York: Teachers College Press, 1969.

Compton, W. Dale. *The Interaction of Science and Technology.* Urbana, Illinois: University of Illinois Press, 1969.

DeVore, Paul W. *Technology: An Introduction.* Worcester: Davis Publications, Inc., 1980.

Drucker, Peter. "Knowledge and Technology." *Dimensions for Exploration Series.* Oswego: Division of Industrial Arts and Technology, State University of New York-Oswego, 1964.

Durbin, Paul T. (ed.). "A Guide to the Culture of Science." *Technology and Medicine,* New York: The Free Press, 1980.

Friedman, Edward A. "Technology as an Academic Discipline." *Engineering Education,* December 1980, pp. 211–216.

Gruender, C . David. "On Distinguishing Science and Technology." *Technology and Culture,* Vol. 12, No. 3, July 1921, pp. 456–463.

Halfin, Harold H. Technology—*A Process Approach.* Morgantown: West Virginia University, Technology Education Program Doctoral Dissertation, 1973.

Harrison, Anna J. "Science, Engineering and Technology" (editorial). *Science,* February 10, 1984.

Hood, Webster F. *A Heideggerian Approach to the Problem of Technology*. University Park: The Pennsylvania State University, Doctoral Dissertation, 1968.

Illinois Institute of Technology Research Institute. *Technology in Retrospect and Critical Events in Science*. Chicago: Illinois Institute of Technology, 1968.

Jarvie, Ian Charles. "Technology and the Structure of Knowledge." *Dimensions for Exploration,* Series. Oswego: Division of Industrial Arts and Technology, State University of New York-Oswego, 1967.

Kranzberg, Melvin. "The Disunity of Science-Technology." *American Scientist.* Vol. 56, No. 1, 1968, pp. 21-44.

Kranzberg, Melvin and Pursell, Carroll W. *Technology in Western Civilization.* Vol. I, New York: Oxford University Press, 1967.

Langrish, J., Gibbons, M., Evans, W.G. and Jevons, R. *Wealth From Knowledge*. New York: John Wiley and Sons, 1972.

Layton, Edwin. "Mirror-Image Twins: The Communities of Science and Technology in the 19th Century America." *Technology and Culture,* Vol. 12, No. 4, October 1971, pp. 562–580.

__________. "Technology as Knowledge." *Technology and Culture,* Vol. 15, No. 1, January 1974, pp. 31–41.

Mayr, Otto "The Science-Technology Relationship as a Historiographic Problem." *Technology and Culture,* Vol. 17, No. 4, October 1976, pp. 663–673.

Michalos, Alex C. *Philosophical Problems of Science and Technology.* (John Ziman, "The Nature of Science and Technology"), Boston: Allyn and Bacon, Inc., 1974.

Mitcham, Carl and Mackey, Robert. *Philosophy and Technology* (Mario Bunge,"Toward a Philosophy of Technology"), Free Press, 1972.

National Science Board Commission on Precollege Education in Mathematics, Science and Technology. *Educating Americans for the 21st Century,* Washington, D.C., 1984.

Ortegay Gasset, Jose. History as a System. New York: W. W. Norton and Company, 1961.

Pacey, Arnold. *The Maze of Ingenuity—Ideas and Idealism in the Development of Technology.* Cambridge: MIT Press, 1976.

Rabi, I. I. "The Interaction of Science and Technology" *The Impact of Science on Technology,* Aaron W. Warner, Dean Morese and Alfred S. Eichner, eds. New York: Columbia University Press, 1965, pp. 9–36.

Roy, Rustum. "STS: Core of Technological Literary." (editorial). *Bulletin Science, Technology Society,* No. 2, 1982, pp. 289–290.

Sahal, Devendra. *Patterns of Technological Innovation,* Reading, MA: Madison-Wesley Publishing Company, Inc., 1981.

Saxon, David S. *The Place of Science and Technology in the Liberal Arts Curriculum*. Washington, DC.: Association of American Colleges, A Report of the Wingspread Conference, June 1982, p. 37.

Schmookler, Jacob. *Invention and Economic Growth.* Cambridge: Harvard University Press, 1966.

Schofield, Robert E. "Comment: On the Equilibrium of a Heterogeneous Social System." *Technology and Culture,* Vol. 6, No. 4, Fall 1965, p. 591.

Shamos, Morris H. "Scientific Literary: Reality or Illusion." ERIC, Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, April 24, 1984, p. 17.

Skolimowski, Henry K. "The Structure of Thinking in Technology." *Technology and Culture,* Vol. 3, No. 3, Summer 1966, pp. 371–390.

Smith, Cyril Stanley. "Art, Technology and Science: Notes on Their Historical Interaction." Vol. 3, No. 3, Summer 1966, pp. 371–390.

Van Melsen, Andrew G. *Science and Technology*. Duquesne Studies. Philosophical Series 13. Pittsburgh: Duquesne University Press, 1961.

White, Leslie A. *The Science of Culture: A Study of Man and Civilization.* New York: Farrar Straus and Company, 1949.

White, Lynn, Jr. *Machine Ex Deo: Essay in the Dynamism of Western Culture.* Cambridge: M.I.T. Press, 1968.

Whitehead, Alfred North. Science and the Modern World. New York: Macmillan Company, 1925, pp. 137–292.

Zvorikine, A. "Technology and the Laws of Its Development." Technology and Culture, Vol. 3, No. 4, Fall 1962, pp. 443–458.

Concepts in Technology: Seeing the Order in the Chaos

Chapter 2

Marc J. de Vries
Eindhoven University of Technology
Eindhoven, The Netherlands
49th CTTE Yearbook, 2000

The speed of technological development is so rapid that what is new today will be old fashioned tomorrow. Technology education textbooks, for example, that are based on individual technical products without teaching basic concepts, will be outdated within a few years of their publication date. It is almost impossible to keep textbooks up-to-date if one really wants to have the newest gadgets included in them. Yet, we do want to prepare our pupils to live in today's technological world, not yesterday's. In fact, we also want them to be able to live in tomorrow's technological world. But a fundamental question remains. If it is so difficult to keep track of current technologies, how can we ever write a textbook that contains tomorrow's technical products and processes? So far, I have mentioned just textbooks—but that is only one of the many teaching and learning resources. In fact, the textbook dilemma I have described holds true for whatever other resources that might be available to technology educators.

Some technology educators feel that in the high tech era of today, it is appropriate to throw away everything related to shop facilities. Unfortunately, even before the 21st century arrives, these same educators will have found their new technologies to be obsolete. Does that mean that shop was okay after all? That is questionable. One of the main motives for introducing high tech stuff was the recognition that teaching technology by making pupils skilled craft workers was not exactly meeting the demands of modern society.

What happens if the traditional shop and high tech approaches do not guarantee a relevant school subject that will prepare people to make sophisticated decisions about technology? Of course, there is no single and unique answer to that question. It is a question, however, that technology educators must continue to address. Whether we are able to teach the basic concepts of technology that remain constant over time, even though their appearance in concrete applications may change, will be important.

Some technology educators even accept this point to be the main basis for defending technology education as a separate subject in the school curriculum. I will deal with that debate here as I think there are additional motives for defending that position. If one could defend that technology is a discipline in its own right and with its own body of knowledge, it does not necessarily mean that it should be taught as such. No, even separate from this whole debate about whether or not technology should have a separate place in the curriculum because of its unique body of knowledge, the quest for basic concepts remains.

How do we justify technology education on a conceptual basis? I think there are three questions that need to be answered. First, what are the basic concepts? Second, to what extent do pupils already recognize these concepts or may have entirely other pre-concepts in mind when they enter our lessons? Third, how can we create teaching and learning situations that enable pupils to adapt their mental concepts so they will be in accordance with real world technological concepts? Let's consider these questions individually.

When science educators search for basic concepts for teaching science, they go to university faculty who are regarded as an academic analog of the school subject. The same holds true for all types of other subjects, but not for technology education. Of course, one could think of the various engineering disciplines, but who would like technology education to be the sum of all those disciplines? Another option that needs to be considered is the philosophy and history of technology. Philosophers and historians have provided a lot of information about the nature of technology, but they are very much in the development stages in putting this information together. Still, it is worth establishing contacts between technology educators and philosophers and historians of technology. My own position is somewhat of an intermediary as I have been involved in technology teacher training for several years. I now find my current research position in the philosophy and history of technology most fruitful for the technology education activities that I continued to develop after I took up my new position. Gradually, I began to see the richness of concepts that related to the nature of technology. This is much more than the concept of systems that by now most technology educators have recognized as basic. In the textbook, *Techno-logisch* (Dutch for technological, i.e., there is a logic and order in technology and it is not merely a chaotic collection of a thousand-and-one devices), my colleagues and I tried to help pupils recognize the order in the chaos by focusing on these types of concepts.

When considering the issue of pupils' pre-concepts, I think technology educators should really be jealous of science educators. Science educators have already established research outcomes to determine what ideas pupils already possess about our subject matter. These ideas match closely with what we consider to be truth from an academic point of view. There is no need to tell pupils what they already understand and it does not make sense to assume an understanding they do not yet possess. The Pupils' Attitude Towards Technology research that Jan Raat and I initiated years ago was a beginning for this type of research. Recent surveys by Karen Zuga at The Ohio State University and others have shown that in the United States there are still very few studies of this type.

Our challenge for the 21st century is to establish a research base similar to that which science educators have established. The research base will inform us of the type of thinking we can expect our pupils to work with when they go through our technology education programs. Once we have the knowledge, we can more effectively extend the scope of the pupils' concepts of technology from products only to all four of Mitcham's (1994) categories of products, knowledge, processes, and volition.

Lastly, there is the question of how we can change pupils' pre-concepts to become more in line with what we would like them to think from an academic point of view. Change requires teaching and learning situations that take into account the answers to the previous two questions. We have lots of experience with making workpieces and we are quite fast in gaining experience in doing project work with our pupils. But how do we create a totality of practical and theoretical activities that enables concepts to grow in a natural and gradual way in the pupils' minds? Sound research studies would help a great deal—maybe just by collecting successful examples and then trying to dig out the secret of their success in terms of the way they have dealt with technological concepts. One point of particular relevance is that general concepts and skills can never be taught or learned in a vacuum, but only in connection with concrete situations. In other words, we cannot teach pupils general problem solving skills by making them solve general problems. We can teach them to solve all types of specific problems, but it is questionable if solving one problem will automatically provide insights and skills for solving the next problem. The same holds true for general concepts. Recognizing a car as being a system may not automatically enable pupils to recognize the television set as a system, also. We need well thought out educational situations in which pupils learn to make that type of transfer.

SUMMARY

In summary, the 21st century agenda for technology education must address three topics: (1) We need to work with technology philosophers and historians to learn more about their ideas of what is the nature of technology and with what concepts technologists work. (2) We need to collect more knowledge about the extent to which pupils do or do not hold awareness of the basic concepts of technology. (3) We need to be creative in finding which teaching and learning situations we can shape that will enable pupils to adapt their own ideas to what we would like them to believe. If we are willing to address these three challenges, pupils will start to recognize the order in the seemingly chaotic variety of technical objects and issues. They also will be able to understand not only yesterday's and today's technologies, but also tomorrow's technologies.

REFERENCES

Mes, P., Smeets, J. & Vries, M. J. de (1998), *Techno-logisch* (2nd ed.). Houten: EPN Publishers.

Mitcham, C. (1994). *Thinking through technology. The path between engineering and philosophy.* Chicago/London: University of Chicago Press.

Vries, M. J. de & Tamir, A. (Eds.) (1997). *Shaping concepts of technology. From philosophical perspectives to mental images*. Dordrecht: Kluwer Academic.

Technology And Society

Section II

STANDARD 2—TECHNOLOGY AND SOCIETY
Technology teacher education program candidates develop an understanding of technology and society within the context of *the Designed World*.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 2. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Compare the relationships between technology and social, cultural, political, and economic systems. • Assess the role of society in the development and use of technology. • Assess the importance of significant technological innovations on the history of human kind.
Performance Indicators:
• Judge the effects of technology on the environment. • Evaluate the relationship between technology and social institutions such as family, religion, education, government, and workforce.
Disposition Indicators:
• Demonstrate sensitivity to appropriate and inappropriate uses of technology and its effects on society and the environment. • Make decisions based on knowledge of intended and unintended effects of technology on society and the environment.

Ethics in a Culturally Diverse Technological World

Chapter 3

Linda Rae Markert
State University of New York at Oswego
Oswego, NY
53rd CTTE Yearbook, 2004

> Professional ethics courses make minor contributions to major needs . . . real world ethics is a complex admixture of personal, social, and professional morality.
>
> Robert J. Nash, 2002, Real World Ethics

> If we are to understand the nature of ethics in a diverse workforce, we must first learn something about the different streams of ethical thought and examine them within the context of diversity.
>
> Willie E. Hopkins, 1997, Ethical Dimensions of Diversity

It is nearly impossible to get through the day without hearing words like global, worldwide, or international at least once and likely several times. Finding a remote place of respite devoid of any connectivity to civilization is similarly difficult for any of us to achieve for any significant period of time. Countless artifacts of science and technology surround us and greatly influence our interactions with other persons on a daily basis. Middle school students routinely (sometimes too often!) have online conversations with individuals around the world whom they may never have met face-to-face, and they believe this is quite normal. High school students are learning to use sophisticated handheld Global Positioning System (GPS) devices in their science classrooms, establishing local connections to distant geostationary satellites and illustrating the outer limits of global systems that even extend to outer space.

Many of us take these daily occurrences for granted, lending further credence to the often-heard assertion that we live in a global society that is intensely interconnected and is, therefore, interdependent. On the other hand, the number of persons among us who have spent extended periods of time away from the United States in an attempt to live among and learn from persons in other countries, is certainly a minority. Stated another way, all of us may be aware that our world is culturally and technologically diverse, but very few of us are able to fully comprehend and articulate what life is really like and about in other places away from our homeland.

The purpose of this chapter centers on an examination of the extent to which ethical values influence the development and transfer of technology around the world. Ethical values include such qualities as integrity, responsibility, fairness, caring, and a dedicated work ethic. The globalization of scientific and technological research and education has created a complex network of partnerships, linkages, joint ventures, and numerous multinational enterprises. Coupled with this reality, the current strong position of the United States as the world's leading producer of high-technology products reflects its success in attending to the needs and desires of a large domestic market, as well as in responding to the demands of foreign markets (National Science Board 2000). In considering the importance of ethics and ethical behavior as a facet of the new technology education standards, the following sections of this chapter provide a brief overview of our own nation's ethical and moral underpinnings, several international perspectives on ethics, and the role ethics in society has played in the development and use of technology in our world.

ETHICS IN THE UNITED STATES OF AMERICA

The term culture, from the Latin word *cultura*, can be used to refer to the amalgam of socially transmitted behavior patterns, beliefs, and other products of human thought that are characteristic of a population. McElroy (1999) suggested that a historical culture can be viewed as a unique set of extremely simple beliefs that are formed and communicated through behavior over more than three generations. Cultural beliefs must be simple to make sense to many people and to be expressed in varying behaviors over an extended period of time. The concept of ethics is derived from the Greek word *ethos*, which Byron (1977) loosely translated to mean internal character. In many instances, the terms ethics and values are used interchangeably. However, distinctions can be made between them. Rokeach (1968) stated that ethics tend to focus on the conduct of individuals, whereas values represent the fundamental beliefs that individuals hold to be true about conduct. Stated differently, values are the underlying beliefs and attitudes that help determine one's actual conduct. Hopkins (1997) further explained that *(a)* a value establishes a moral standard for an individual such that action may be taken to achieve a goal, and *(b)* the purpose of an ethic is to ensure that the action designed to achieve a goal will be done without violating a value. The term morals, or the concept of morality, is also used as a synonym for ethics. Once again, *ethos* from the Greek language is translated into what may be called internal character. However, the Latin translation of ethos is *mos, moris,* from which the term moral is derived and seems to shift the focus from internal character to observable behaviors (for example, actions, habits, traditions, or customs). Figure 3–1 illustrates the relationships between culture, ethics, values, and morals.

Figure 3–1. Relationships between culture, ethics, values, and morals.

The dictionary defines teleology as the philosophical study of design or purpose in natural phenomenon. The Greek word *teleos*, meaning "end" or "issue," is the root word. Teleology is the underlying premise for utilitarianism, one of the ethical frameworks presented in Chapter 1. Hopkins (1997) asserted the following:

> Teleological theories of ethics hold that whether an act is morally right or wrong depends solely on how good or bad the consequences of the action are for oneself . . . . The teleological perspective on ethics argues that acts are morally right or good if they produce some desired state of goodness or pleasure and are morally wrong or bad if they produce some undesirable state of badness or pain. Subsequently, the rightness or wrongness of actions is determined by the results that these actions produce and not the act itself. (p. 26)

Historians of American culture grapple with this question: In our contemporary technological society, how is it that so many different people who have widely disparate, diverse, and often dissimilar ideas and customs are able to get along as Americans (McElroy, 1999; Wolfe, 2001)? The unity of this vast and diverse nation we know as the United States of America has evolved over many generations because common behaviors based upon strong principles/values have endured. The earliest experiences of the American colonists on the continent's Atlantic coastal plain region were nearly unbearable. These pioneers confronted a veritable wilderness where they had to devise ways to build communities and survive together in a harsh environment. Generations of individuals labored diligently to transform an expansive rough country and shaped the history of America. McElroy thus concluded that it truly was (and continues to be) work that shaped (shapes) the primary beliefs of the American people, because the most important task for generations of settlers was survival, and those who did not work could not survive.

If we can acknowledge McElroy's (1999) conclusion that the primary beliefs of American culture are directly related to work, we might be persuaded to agree with these simple tenets: *(a)* "everyone must work," *(b)* "people must benefit from their work," and *(c)* "manual work is respectable" (p. 37).

Our country was from the earliest beginning a society of workers, and it remains so to this day. Most of us learn when we are quite young that work is respectful, and we should endeavor to be successful and self-supporting. The beliefs about hard work that have developed over time in our culture make it feasible for an electrician in twenty-first-century America to earn a higher salary than a university professor and be an equal member of the middle class. The development of our civilization from a brutal wilderness made America, as Benjamin Franklin labeled it, a "Land of Labour" (cited in McElroy, 1999). Beyond our reverence for work, ethical behaviors in the United States are based largely on the principles of freedom, equality, individuality, responsibility, improvement, and practicality (McElroy).

BELIEFS OF AMERICA'S FOUNDING FATHERS

Politically and socially active during the last quarter of the eighteenth and first decade of the nineteenth centuries (roughly 1774 to 1809), the Founding Fathers were the group of men who created the American Republic. Three major spheres of activity in which these men participated collectively were the American Revolution, the Constitutional Convention of 1787, and the establishment of the federal government in 1789 (Padover, 1960). Generally speaking, the Founding Fathers were solid citizens, who were respected in their community, and usually of good family background. "Of the signers of the Declaration of Independence, the Articles of Confederation, and the federal Constitution, nearly half were lawyers and at least fifteen were businessmen . . . five were physicians . . . and sixteen, among them the learned and brilliant James Madison, had no profession other than politics" (p. 28). The majority of these men were native born, almost entirely of British (including Irish) heritage.

The prevailing intellectual climate of their era was that of the eighteenth century Enlightenment—with its emphasis on reason and demonstrable scientific truth. This environment gave potency and philosophic meaning to the daily experiences of an emerging new man—the practical, sensible, down-to-earth, energetic doer and builder: the American. The social, political, and economic realities of the decades immediately following the American Revolution were a driving force for the creation of a strong, centralized government headed by a powerful chief executive. The Founding Fathers' ideas contained in Article II of the Constitution continue to shape the presidency in our country to this day (Bunch et al., 2000).

The spiritual world of America's Founding Fathers was predominately one of Protestantism. The Protestant roots were deep, even for those men who were not religious and who did not belong to any established church (Padover, 1960). They collectively displayed Calvinistic beliefs in their stubborn sense of personal independence and systematic refusal to accept authority without questioning it. John Adams is quoted as saying that the hatred of the Church of England "contributed as much as any other cause to arouse the people against Britain's political authority" (cited in Padover, 1960, p. 45).

This Protestant tradition of dissent eventually culminated with the Founding Fathers' establishment, first in principle and then in practice, of the separation of church and state. To the extent that spiritual liberty is the first of all personal liberties, the permanent disestablishment of the church from government was one of the Founding Fathers' greatest achievements. "An official religion, that is, a church for which the people are compelled to pay taxes regardless of their own beliefs, produced, the Founding Fathers felt, a chain of evils of which the foremost were the denial of the free exercise of reason and the perpetuation, through coercion, of moral hypocrisy" (Padover, 1960, p. 45). Take a brief moment to consider the following quotes, relative to the separation of church and state, written or expressed by four of our country's Founding Fathers:

> *George Washington (1732–1799)*. We have abundant reason to rejoice that in this Land the light of truth and reason has triumphed over the power of bigotry and superstition, and that every person may here worship God according to the dictates of his own heart.

> *John Adams (1735–1826).* The United States of America have exhibited, perhaps, the first example of government erected on the simple principles of nature; and if men are now sufficiently enlightened to disabuse themselves of artifice, imposture, hypocrisy, and superstition, they will consider this event as an era in their history.
>
> *Thomas Jefferson (1743–1826).* Everyone must act according to the dictates of his own reason, and mine tells me that civil powers alone have been given to the President of the United States, and not authority to direct the religious exercises of his constituents.
>
> *James Madison (1751–1836).* And I have no doubt that every new example will succeed, as every past one has done, in showing that religion and government will both exist in greater purity, the less they are mixed together.
>
> (Words of our American Founding Fathers, 2002)

In summation, this nation's Founding Fathers were men of strong convictions, who were animated by a deep moral conscience and devoted to the ideal of freedom. Their world was ruled by reason, pragmatism, and the philosophy of natural laws. Still, their regard for personal spirituality was evident. Our American Republic was crafted by these men on their intrinsic belief that it was forever possible for people to govern themselves without abuse or injustice (Padover, 1960). Most assuredly, their views of the world resulted in a democratic system of government that ultimately became friendly to capitalism and technological development in our nation.

THE PROTESTANT WORK ETHIC

Any discussion of ethics in the United States of America would be grossly incomplete without serious mention of what is commonly referred to as the Protestant Work Ethic (PWE). Generally speaking, the PWE is respected as a code of morals that are based on the principles of thrift, discipline, hard work, and individualism. The person to whom most credit is given for the formulation of the PWE is the German political philosopher and economic sociologist Max Weber (1904, 1905). He perceived and examined the close relationship between the Protestant ethic and the rise of capitalism.

Furnham (1990) suggested that Weber understood capitalism as a mass phenomenon, a culturally prescribed way of living, and a moral doctrine to advance individuals' material interests. Weber (1904, 1905) himself stated that capitalism is "the rational and calculated expectation of profit by the utilization of opportunities for exchange" (p. 22). Weber took great interest in the fact that capitalism had developed mainly in those areas of Europe in which Calvinistic Protestantism had taken a foothold early in the Protestant Reformation. In his quest to build a case that a causal relationship existed between religion and economic life, Weber's work gained much notoriety, and his thesis has survived as one of the best known and also quite controversial works in the social sciences.

Persons who belonged to the Protestant faiths were intensely anxious about their state of grace with God, largely due to the doctrine of predestination, which is central to Calvinism. Those who believe in predestination realize that God's grace is as impossible for those to whom he has granted it to lose, as it is unattainable for those to whom he has denied it. Therefore, persons spent considerable time worrying about whether they were one of the elect and certain of everlasting life. A practical means of reducing this anxiety took the form of a systematic commitment to a "calling"—that is, to hard work, thrift, and self-discipline. Material rewards recouped as a result of this work were to be saved and reinvested. Ultimate success in the commercial world tended to have a reassuring effect for individuals because they believed they were safely in God's good grace. Stated another way, persons who worked hard, practiced frugality, and were outwardly successful could be assured of a blessed afterlife.

Oates (1971) seems to concur with this summation in his interpretation of Weber's monumental work. He makes the following statement about the PWE:

> The so called Protestant Work Ethic can be summarized as follows: a universal taboo is placed on *idleness,* and *industriousness* is considered a religious ideal; waste is a vice, and *frugality* a virtue; *complacency* and *failure* are outlawed, and *ambition* and *success* are taken as sure signs of God's favour; the universal sign of sin is *poverty*, and the crowning sign of God's favour is *wealth*. (p. 84)

Without question, the idea of the Protestant ethic has significantly influenced our nation's history, sociology, and political science. Throughout the last quarter of the twentieth century, however, ethics have become more secularized and seem to be less tied to spiritual convictions.

Several examples of contemporary ethics were discussed in the research completed by Maccoby and Terzi (1979). They argued that the Puritan ethic, craft ethic, entrepreneurial ethic, and career ethic have developed sequentially in America and are all related to one another. The career ethic, perhaps most evident in contemporary society, "emphasizes meritocracy, talent, and hard work within organizations leading to success and promotion. This ethic implies an other-directed, ambitious, marketing character" (Furnham, 1990, p. 15). As you can see, there remain vestiges of the Protestant ethic, but they are more or less devoid of the salient link to God's grace and the life hereafter.

Another ethical philosophy that emphasizes a worldview based on natural phenomena is labeled secular humanism, a term that has come into use in the last 30 years. Secular humanists accept a philosophy called naturalism, in which the physical laws of the universe are not superseded by supreme beings, such as demons, gods, or other spiritual entities outside the realm of the natural world (Kurtz, 2002). They view ethics as an autonomous field of inquiry, independent of theological claims, amenable to rational scrutiny, and espouse testing value judgments by their consequences.

Although secular humanism is apparently at odds with faith-based religious dogma on many issues, its proponents state it is dedicated to the fulfillment of the individual and humankind in general (Council for Secular Humanism, 2002). In sum, secular humanists do not rely upon gods or other supernatural forces to solve their problems or provide guidance for their behavior. Therefore, secular humanists do not believe in God or an afterlife. Secular humanism encourages people to think for themselves and question authority, and suggests that the morality of our actions should be judged by their consequences in this world (Cherry and Matsumura, 1998).

To a large degree, the backdrop of the Founding Fathers, the PWE with endorsement of hard work, and the influences of secular humanism explain the prominence of utilitarianism in the American legislative and judicial systems. The principle of basing decisions on the greatest amount of good for the largest number of people is very pragmatic and allowed people with diverse belief systems to successfully establish a democratic system of governance.

IMMIGRATION AND AMERICAN ETHICS

E Pluribus Unum is our national motto, meaning “from many, one.” It was originally conceived to describe and celebrate the unification of 13 states into one union. Throughout our country’s history, this phrase has often been used to exemplify the fact that the vital and vibrant unity of our much larger national community is founded on individual freedom and the diversity that emanates from it.

More than 55 million immigrants have made the choice to leave their homelands and resettle in America over the last four centuries. This fact represents the largest movement (most often voluntary) of human beings to any one place in the history of mankind (McElroy, 1999). Restrictions on immigration to the United States were not enacted to any significant legislative extent prior to the early twentieth century. Contemporary immigration policy in our country is written in the Immigration Act of 1990 (P.L. 101–649), and a considerable volume of migration to America continues as we enter the twenty-first century. Historically, most Americans have either been immigrants themselves or descendants of immigrants; therefore, the beliefs and behaviors of persons from many foreign lands have had a fundamental and determining influence on the formation of American culture, ethics, values, and morals.

The long-term effects of immigration are complex, numerous, and diverse. Immigrants contribute to the social fabric of the United States in countless ways: *(a)* to its vibrant and diverse communities, *(b)* to its lively and participatory democracy, *(c)* to its vital intellectual and cultural activities, *(d)* to its renowned job-creating entrepreneurship and competitive marketplaces, and *(e)* to its family values and strong work ethic (U.S. Commission on Immigration Reform [USCIR], 1997). Our current policies regarding immigration are regulated such that priorities for admission are established, reunification of nuclear families is facilitated, U.S. employers are given access to a global labor market while ensuring that current U.S. workers are not displaced, and we are able to fulfill our commitment to principles of humanitarian protection and assist in the resettlement of refugees.

Immigrants to the United States prior to the 1800s were almost entirely from Europe; since that time, increasing numbers of persons from Asia, Africa, and Latin America have immigrated to this expansive nation. Today, the majority of immigrants being admitted represent cultural groups from Asia, the Caribbean, Mexico, and Central and South America

(Hopkins, 1997). Regardless of their country of origin or the century during which they came, these millions of immigrants traveled to America in search of a better and much improved life for themselves and their families. McElroy (1999) surmised that these diverse groups of immigrants brought with them three simple beliefs, which their behaviors and decisions as resettled citizens demonstrated: *(a)* "improvement is possible," *(b)* "opportunities must be imagined," and *(c)* "freedom of movement is needed for success" (p. 61).

Ostensibly, if persons who migrated to a new land to start a new life possessed these beliefs prior to their arrival, they would likely be prepared to adjust to the social and ethical beliefs of the new land. These three beliefs represent a framework that allowed diversities of nationality, language, and religion to be gradually amalgamated into a new American identity (McElroy, 1999). Throughout our history, each immigrant and immigrant group has had a unique set of experiences in America, distinctive to the individual person or group. The process of becoming an American is most simply called "Americanization" and it entails personal choices and meaningful decisions.

There exists no mandate that everyone who immigrates to the United States must dismiss the customs and practices brought with them from their homelands. The fact that most immigrants hold onto their native customs to some extent actually makes the face of our nation all the more intriguing. On the other hand, according to classical assimilationist theory, the best option for newcomers to a given society is to shed their ethnicity as quickly as possible (Hopkins, 1997). Evidence exists that most immigrants "choose an option that is somewhat less drastic, and they either *(a)* assimilate the mainstream's cultural values, *(b)* assimilate a particular minority's or subculture's values, or *(c)* preserve their own cultural values" (p. 58).

The concept of ethnic culture has developed alongside the continuing waves of immigration over the years. This idea illustrates a component of ethnicity that refers to a pattern of unique behaviors, beliefs, and ethics that sets a cultural group apart from others (for example, Native Americans, Hispanic Americans, Asian Americans, and African Americans). The process of Americanization and patterns of cultural differences can be studied via the lenses of both assimilation (as previously noted) and deculturation. Under assimilation, the contention is that members of ethnic cultures (immigrants) adapt their behavioral patterns, values, and norms to those of the dominant culture. In so doing, these individuals may camouflage their true feelings and actually suppress aspects of their own culture while in public. Under deculturation, members of ethnic cultures (immigrants) retain their distinct set of norms and values with no attempt to integrate or synthesize the value system (ethics, morals) of the dominant culture (Hopkins, 1997). A primary example of deculturation is the presence of a vibrant "Chinatown" in the middle of any large American city, where there is minimal interaction between the residents of Chinatown and persons residing outside that small community.

Regardless of the process used to become an American, immigrants have exposed this nation to a wide array of cultures and have built our undisputed reputation as a conglomeration of people from around the world. Immigration is a central theme in the story of the United States of America. The beliefs of our Founding Fathers underlie our core values and have formed our ethics and morals. Through the years, millions of immigrants have subscribed to a good work ethic, strong family values, and a belief in freedom and justice for all citizens. It is important for us today to recognize that although we are a nation as one whole, it is really the unique and diverse individuals who make the whole so strong and appealing to others who reside outside our land (*E Pluribus Unum*). The following section of this chapter presents an array of international perspectives on ethical behavior and describes some of the external perceptions different ethnic groups have about persons who call themselves Americans.

INTERNATIONAL PERSPECTIVES ON ETHICS

The current state of world politics and international agreements give credence to the fact that cultural awareness is extremely important in contemporary society. As noted earlier, the number of American citizens who have spent extended periods of time living with and learning about persons from other cultures is rather small. Regardless, those Americans who are traveling abroad and experiencing other cultures and customs undeniably make an impression on those persons they meet on foreign soil. When diverse cultures meet, it is not uncommon for misunderstandings, misconceptions, and erroneous assumptions to arise. Because the United States is commonly viewed as the last remaining superpower, Americans are perhaps the most loved, hated, envied, appreciated, and resented persons on the planet. Perceptions such as these become evident when Americans visit other nations and when foreign visitors take time to explore the United States.

When persons of foreign nationalities visit the United States, they often notice the goodness of the average American citizen. The fact that immigrants perceive America as providing freedoms and opportunities being denied to them in their homeland makes the United States a highly desirable destination. Foreign students studying in American universities or high schools remark that their classmates are helpful and find their empathy, candor, humor, and hard work to be worthy of great notice. Hopkins (1997) suggested that "Americans are often viewed by members of other cultures as being very informal, direct, competitive, achievers, questioners, punctual, and obsessed with cleanliness," whereas "Americans view themselves as being caring and generous people who value their independence and entrepreneurial spirit" (p. 44).

Realistically, it is impossible to deny the existence of anti-American sentiments around the world, both now and in decades past. Hussain (2001) concluded that negativism about America has largely been derived and shaped by popular perceptions in three areas: *(a)* dignity, *(b)* double standards, and *(c)* democracy. He surmised that the aforementioned American goodness is not generally exported, remaining principally confined to its homeland shores. He further stated that the ethics and values Americans purport to be true at home—liberties, rule of law, and democracy—are rarely exemplified in American foreign policy (Hussain). Graham Fuller, who is former vice chairman of the National Intelligence Consulate of the Central Intelligence Agency, in an interview before the U.S. Department of State, stated the following:

> There is a huge cadre in the Middle East of people educated in the United States at the university level who have the warmest and fondest memories of this country. You can meet hundreds of them at any gathering. They will tell you about their time all over this country, in the Midwest the hospitality they encountered, their admiration for Americans' political values for democracy, for human rights, for minority rights, this kind of thing. But they say, "We do not recognize your country when we see your policies in our part of the world. We don't see these American values reflected at all." (Commission Reviews Middle Eastern Perceptions of the United States, 2002).

The horrific terrorist attacks on the United States in September 2001 drew renewed international attention to the concept of anti-Americanism.

The deliberate strikes against deeply symbolic and valued objects in America terrified observers and citizens by the sheer force of hatred directed at the United States (Gudkov, 2002). Dislike of America is consistent with the common irritation an impoverished civilization experiences toward a wealthy and powerful neighbor nation. In many ways, the incredible, and perhaps intolerable, success of the United States during the twentieth century made it the technological and economic leader of the world. At the same time, persons from other nations, citizens and leaders alike, experienced grating envious reactions characterized by the question, "Why not us?"

We live in an interconnected society wherein the continuum of technological prowess and development is expansive. Behaviors and decisions with regard to foreign relations and agreements may not always be ethical by one's personal definition, however much we hope they should or will be. Perspectives of leaders in other nations relative to ethics are important to understand and acknowledge as we enter into numerous exchanges involving the transfer of science and technology.

Ethics in Africa

Around the world, we can find examples of great concern regarding ethics and corruption. Leaders in some regions are particularly interested in finding ways to mitigate the damaging effects unethical and dishonest practices have had on the technological and economic development of their countries. Africa currently faces enormous challenges in its efforts to achieve sustainable human development. This continent is home to many of the world's poorest countries and it is overwrought with endemic diseases, such as malaria and HIV/AIDS. A significant percentage of Africans also live in countries experiencing severe civil conflict and unrest (United Nations Department of Economics and Social Affairs Division for Public Economics and Public Administration [UN/DESA/DPEPA], 2001).

There are certainly pockets of gain and improvement in various parts of this vast continent in the world's southern hemisphere, but overall, prospects for development are not very promising. With declining export shares of primary commodities, a lack of viable manufacturing and service industries, along with capital flight and brain drain, Africa's position in the global economy continues to falter (UN/DESA/DPEPA, 2001). The paramount preconditions to Africa's capacity for sustainable development appear to involve improving governance, resolving conflict, and attending to the critical medical and health needs of the populace.

The nature of human existence in Africa is communal, and it is a reality that heads of households, officers of spiritual associations, and various religious specialists are viewed as moral guardians of their families, groups, and society at large. They are regarded as guardians of the moral order of the universe through their observance and transmission of both life and tradition. Similarly responsible on a substantially higher level are Africa's kings, chiefs, clans' leaders, and other types of authority figures whose power extends beyond the family or the small community.

Magesa (1997) explained that the concepts of law and politics are ambiguous when applied to African organizations because they cannot be easily extracted from the religious moral and ethical systems. Stated another way, in traditional African countries, there is generally no specific political structure that is distinct from the social and religious organization in society. When persons occupy political and religious positions of some importance in Africa, their political power is visibly reinforced at those points in the seasonal cycle, or the group's developmental cycle, where ritual officership gives them enhanced authority (for example, during a religious day of atonement; Turner, 1966). African leaders who are at the higher social levels of the lineage, clan, or ethnic group personify the order of the world and the harmony that enables life to continue. They believe their primary purpose as leaders is to guard the power of life in the community (Magesa).

Law and resolution of conflict in African societies are integrally related to the entire system of morality and ethics practiced in African religions. Gluckman (1965) asserted it is difficult to separate law (governance) from custom, taboos, divination, mediumship, ordeals, and the expectations of sharing, harmony, play, and good company in general. Magesa (1997) elaborated on this notion of good company stating it "implies community, that is, the establishment and maintenance of harmonious relationships among people…and includes the exchange of aid and sympathy which spring from personal friendship" (p. 259). Good company, practical sharing, communion, and communication are essential factors of African political systems. The African legal system and moral code of conduct are inextricably linked, and resolution of conflict is commonly connected to religious practices and beliefs.

African religion emphasizes the communal nature of property within a given community reflecting the principle of inclusion. It does not dismiss private or personal ownership, but the ethical task is to establish a balance between the rights to private ownership of property and the human understanding of the resources of the universe (Magesa, 1997). In African religious thought, the right of personal ownership resides within the context of joint or public right of access to the basic resources that are essential for life. For example, when any form of tribute is given to the chief or other leader of the community (for example, cattle, grain, water, or labor), it is paid to them in trust for the entire community. Africans believe that there are some resources that are gifts from God to all human beings and, therefore, cannot be privately owned. Land is a primary example which Africans regard as an absolute source of sustenance, and it may only be held in trust. Society entrusts pieces of land to individuals or groups for their own use but also for the greater society's well-being, growth, and development (Magesa).

In summation, the African religious worldview emphasizes relationships and centers on the fact of creation. God, through the act of creation, is omnipresent in the entire universe. Humanity, at the center of the universe, is firmly connected to all living and nonliving creations by means of each creature's life force. Africans believe that God, spiritual beings, ancestors, humanity, living things, and nonliving things possess life forces with greater and lesser powers, and all forces are intertwined (Magesa, 1997, p. 285). From birth to death, African religion pays special attention to all the rights of passage marking different stages of development of these life forces. Economic activities and political agreements, by their relation to life itself, come to be viewed as religious events.

Ethics in Asia

Similar to what we find in African nations, a common thread woven through Asian cultures is the strong influence of dominant religions, such as Confucianism, Taoism, and others in the countries aligned with China's ideals, and of Buddhism and Shintoism in Japan. A value emphasized in these religions is social interaction, which Hopkins (1997) suggested is the basis of the strong group identification, formality and courtesy, humility, and taciturn demeanor for which Asian cultures seem to be known.

In Asian business organizations, the prevailing values highlighted by corporate culture are loyalty, accommodation, and honoring authority. One example is exemplified in Korea's family-run conglomerate. The founder of Samsung wrote an employee policy in 1938 explaining that loyalty to the organization would be highly valued in all workers (Andrew 1988). Policies like this are evident in many Asian firms, and, in terms of the accommodation ethic, Asian employees generally try to minimize dissent and avoid confrontation. Asian organizations tend to be very hierarchical, and the chain of command is clearly defined and respected. Employees who are working in the lower levels of the company are extremely careful to not offend individuals of higher authority or of greater age.

Enderle (2000) suggested that Confucian ethics are the spiritual source for and exist at the heart of the economic successes experienced in the Asian countries of Taiwan, South Korea, Hong Kong, and Singapore. Cua (1992) explained that Confucian ethics is a form of virtue ethics. The goal is a well-ordered society based on good government that is responsive to the needs of people, to issues of wise management of natural resources, and to just distribution of burdens and benefits (Enderle). *Tao* is the ethical ideal of a good human life that underlies Confucian ethics and stresses character and personal formation or cultivation of virtues. These virtues consist of *(a)* the basic independent virtues of love and care for one's fellows, a set of rules of proper conduct, and reasoned judgment concerning the right thing to do; and *(b)* the dependent virtues of filiality, respectfulness, and trustworthiness (Cua).

In Japan, there are some cultural values and ethical behaviors that are not replicated in other Asian cultures (Hopkins, 1997). The influence of Confucianism can be seen in their emphasis on hierarchy and position, whereas the subtle and indirect demeanor and hidden meaning in the Japanese disposition is linked to Zen Buddhism. Japanese persons view themselves as members of a group first and then as individuals, and they do not enjoy being singled out to be praised or congratulated. In Japanese organizations, employees are expected to get along in a group environment, to adhere to the established formalities, to respect the clear class distinctions, and to behave in a conventionally predictable manner (Goodman, 1990).

The cultural value system and ethics are dominated by the qualities of sameness, evenness, and consistency. Corporations doing business in Japan foster norms that focus on courtesy, conformity, and caring for others. Harmony is of paramount importance (Hopkins, 1997). Deference and respect are based on age, rank, role, and gender. The suppression of women in these corporate settings is another salient factor that characterizes the value system of Japanese organizations.

The Republic of India, a sprawling land of contrasts and seeming contradictions, is home to a large number of diverse ethnic communities. Since becoming independent in the late 1940s, the Indian government's basic philosophy of development has been self-reliance. The dominant religion in the country is Hinduism, but substantial minority religions are practiced including Islam, Sikhism, Jainism, Buddhism, Christianity, and Judaism. Indian ethics and value systems do not assimilate these many different cultures, customs, beliefs, languages, and religions into a unified whole—each exists and is accepted as they are (Hopkins, 1997). Included among the values of the middle class are respect for education and competitive excellence. As in other Asian countries, there exists in India a deep regard for age and social position. One of the best known aspects of India's cultural structure is the caste system, which prescribes social status at birth and offers no opportunity for upward mobility.

Although employees in Indian business organizations appreciate the concepts of time and protocol, appointment schedules are not always strictly adhered to, and perspectives toward work are somewhat more relaxed than in most other Asian cultures (Singh and Hofstede, 1990). Formal titles are used almost all the time, but upper-level Indian managers seem generally inclined to use consultative and participatory styles of decision making. At the lower levels of the organizational chart, however, managers seem to be more autocratic, and sharing any power with one's subordinates is viewed as a weakness (Singh and Hofstede).

Ethics in Europe

According to Swenson (2000), business ethics programs are now receiving greater attention in Europe. He noted that in the early 1980s less than 20 percent of the major corporations in Germany, France, and the United Kingdom had a published code of conduct. By the early 1990s, that population of firms had increased to the 50 percent mark. Swenson went on to say that codes of ethics are not necessarily a panacea for unethical behavior, but they represent a good starting point.

A large number of countries make up the geographic region of Western Europe. In contemporary society, it is apparent that the European Union stands together with the United States in a deep-rooted commitment to promoting shared values of democracy, human rights, and fundamental freedoms in our world. Both parties promote the advancement of the common goals of peace, development, and prosperity. A strong foundation for substantial and influential dialogue on foreign policy issues is in place for today's political leaders in the European Union and the United States. The ethics and values of two Western European countries—France and the United Kingdom—are discussed briefly, to provide a partial profile of this region's perspective on ethics. As noted earlier in the discussion of ethics in the United States of America, many of the early immigrants to America emanated from these European nations. For this reason, we see similarities in their beliefs and value systems.

Generally speaking, persons in Western Europe tend to be rather formal and conservative, and commonly refrain from using an individual's first name without invitation (Hopkins, 1997). Punctuality is viewed as a sign of courtesy in this region of the world, and persons holding academic titles or degrees expect them to be used as signs of respect (for example, doctor, chancellor, dean, professor, rector).

The predominant religious background of most people in both France and the United Kingdom is Christian—France being mostly Roman Catholic and the United Kingdom primarily Anglican. The ethical commonalities between these affiliations include a respect for discipline and responsibility, a low tolerance for ambiguity, a view of oneself as an individual first and then as a member of a larger group, high mobility, and great esteem for formal education (Hopkins, 1997).

The ethnic population of France is a broad blend of many different groups—among them Celtic, Latin, Nordic, and North African Arabs. It is largely due to this diverse ethnic pool that French persons consider themselves members of a family first, then citizens of France, and finally members of organizations. The French culture exudes a flair for the arts, performance, and the joy of living. The concept of success in France is not linked to a person's direct accomplishments, but is commonly aligned with her or his educational level, family heritage, and financial status in society (Hopkins, 1997).

The ethnic mix evident in the United Kingdom is primarily English, Scottish, Irish, and Welsh, with considerable numbers of individuals from West India, East India, and Pakistan. Despite this diversity of cultures, Hopkins (1997) explained that a basic sense of fair play underlies this nation's ethics and value systems. The British seem to be an aloof group, but their demeanor is more a reflection of privacy and personal modesty coupled with a desire to not display too much emotion in public. The melding of democratic principles with a much adored monarchy in the United Kingdom has created a culture that is quite formal and conservative, but one that continues to value personal space and independence.

In European firms, a strong concept of social order and emphasis on rules are evident in the corporate value system (McLaughlin, 1990). Management is formal and hierarchical, but many instances of companies in operation throughout the European Union have a less rigid and more egalitarian structure, in ways that truly resemble organizations presently operating in the United States (Hopkins, 1997).

Ethics in Latin America

Individuals from Latin cultures reside in a variety of countries, including Mexico, South America, Central America, and the Caribbean. Collectively, their common Spanish ancestry bonds them. The predominant religion in these nations is Roman Catholic, which plays a significant role in their similar and often overlapping views regarding ethics and values. Family is a very high priority in Latin countries, and family obligations often supersede business responsibilities. Two vehicles that are essential to social mobility in Latin America are marriage and education (Hopkins, 1997). Also of great significance in Latin cultures is one's social position, which effectively determines the extent to which others in your community respect you. As in other regions of the world, education, well-mannered behavior, and land ownership are indicators of a person's social status.

The value system in Latin American companies typically emphasizes status and rank. Loyalty is expected, and there is great respect for managerial authority. Gomez (1993) explained that participative management style is not prevalent because that type of behavior makes Latin workers feel somewhat uncomfortable. Formality is important, but time and perspectives on work are quite relaxed in most Latin organizations. The practice of handing out gratuities or bribes for getting something accomplished is considered legal; these behaviors are an expected way of doing business in Latin firms (Hopkins, 1997). The custom of nepotism is common in Latin American companies, and it is not considered unethical behavior. It further illustrates the prominence of family in Latin cultures.

Mexico is one example of a Latin American country in which efforts have been made to transform its governmental and corporate institutions. In recent years, Mexico's economy has opened to free trade, subscribing to world organizations and agreements, and further encouraging direct foreign investment and private sector modernization (Organization for Economic Cooperation and Development [OECD], 1995). The government has reduced its size via the sale and auction of public corporations, thus promoting more activity in the private sector. Major political changes have occurred, electoral procedures are more transparent, and Mexico's democratic life has been strengthened. These changes have had an impact on Mexican society, its values and principles, and ethics within the public sectors (OECD). In Mexico, the stated moral principles of the public office are legality, honesty, loyalty, impartiality, and efficiency. This manifests a code of conduct that all public servants must observe. In the private sector, companies have also been paying more attention to developing and maintaining ethical standards among their workers. Attention to ethics in Mexico is currently viewed as critical to success in business (Adler, 2002).

ETHICS AND TECHNOLOGICAL DEVELOPMENT IN OUR WORLD

Throughout this chapter, we have examined a wide array of philosophical beliefs, religious convictions, and expected social behaviors. Each of these has been discussed within the context of culture and ethics. In this section, we discuss the impact ethics and ethical behavior have on the development of a technological world in which we can all live. The authors of the CTTE yearbook introduce an array of more specific examples of ethical behaviors as related to the design and development of various technologies (for example, medical, agricultural, and transportation).

The relationship between society and its scientific and technological establishments is both simple and complex. Bird (2002) noted that members of the scientific and technical communities are part of society and are both honored and granted the privilege of pursuing their professional interests in large measure because of their contribution to the good of society. A major responsibility of professionals in science and technology is to ensure the accuracy and reliability of the information they develop, especially with regard to knowledge provided to persons in leadership/decision-making roles (Bird). We have looked at what are considered to be ethical and moral behaviors throughout this chapter. Examples of unethical behavior are discussed in other chapters of this yearbook, but it is essential to review several of them here as they relate to scientific and technological development.

Contemporary science and technology have created the amenities of modern civilization. In countless ways, each has increased our capacity to control environmental forces and has given us visions of an even more prosperous future. Undeniably, science and technology have also increased both uncertainties about the future and our dependence on the numerous inventions and innovations produced. Stated differently, although we may have increased our ability to understand, predict, and control the natural environment around us, we may have actually lost the capacity to control the technologies we have created to help us out along the way. Swearengen and Woodhouse (2001) surmised the following:

> When negative consequences (of technological innovations) are immediate, stakeholders sometimes can assess costs and negotiate remedies and compensations—although when the costs and benefits accrue to different communities and demographic (ethnic) groups, both analysis and remediation can be difficult. When negative impacts of technological change manifest only after lengthy delay during which the offending technology is thoroughly adopted into commerce, correction becomes much more difficult. (p. 15)

Technology and its impact on society at large has been a prevalent theme in social, economic, and political thought for decades. Numerous essayists have debated about the extent to which continued technological growth will either enhance or hinder the survival of the human race. A diverse collection of writers has drawn our attention to the increasing complexity and rate of technological change in contemporary society. Almost habitually, they seem to be making projections filled with varying degrees of alarm. Their publications present the specter of an increasingly uncontrollable technology whose consequences cannot always be assessed or accurately predicted. We are drawn to infer that the human race is on a collision course to ruin and imminent destruction. Members of society must ethically examine the process of technological change and take actions to curtail its destructive and perhaps unintended consequences.

We are living amidst an array of technologies some persons contend are simply accidents waiting to happen. When the dark side of technology reveals itself, when disaster hurts innocent bystanders, and when technology causes more problems than it solves, society often points the finger of blame at its creators. When "accidents" do occur, the general public shakes its head while wondering what is happening to its "technological fix." Regardless, there is little chance that the industrialized nations of the world will turn their backs on the promises aligned with new technologies. We have all chosen a lifestyle sustained by high technology, but that doesn't mean we are not apprehensive about it (Markert and Backer, 2003).

Most of us place our faith and trust in the scientific and technological experts, and we assume that their research practices are ethical. Science and technology are not isolated; they are embedded in the context of social values, human interests, and political objectives. As such, they are subject to public scrutiny using ethical and social norms. Several perspectives on the types of actions we should regard as improper behavior in the arena of science and technology laboratories are presented in Drenth's (2002) work. He distinguished the following four subcategories of behaviors considered to be unethical in the conduct of scientific and technological research:

1. Unethical behavior including fraud (fabrication and falsification of data), deceit (deliberate use of improper sampling techniques), and infringement of intellectual property rights (plagiarism).
2. Improper or imprudent behavior vis-à-vis subjects, including not taking full account of the requirement of informed consent, open or hidden discrimination, and negligence of duty to exercise care in animal research.
3. Careless behavior with respect to the general public and the media, such as too optimistic or unjustified popular reports and interviews, negligence in cases of misquotations by the press, and taking no action in case of wrong or biased interpretations by colleagues or in the media.
4. Disregard of good practice rules such as justified authorship, proper sequence of authors on a published (or working) document, proper citations, correct dealing with secrecy or delay of publication in the interest of the research sponsor, and avoiding conflicts of interest.

Indeed, these examples may seem overly simplistic, but the high stakes consequences of this type of misconduct in a world in which the pace of technological innovation is so accelerated are beyond dire. In many ways, the extent to which human beings around the world in all cultures are able to experience their lives as meaningful and satisfying is directly related to the practice of ethical and moral conduct across the entire landscape of science, technology, and engineering disciplines. Drenth (2002) defended the need for more international scientific and technological collaboration on the grounds of moral (and ethical) obligations of the Western and economically advanced countries to support and strengthen research and development capabilities in economically less developed nations. In the long run, aid and collaborative partnerships, focused on ethics and research themes that have an international character (for example, environment, health, infectious diseases, trade, transportation, security), will likely become the best precondition for peaceful coexistence in our world.

The most critical ethical challenges of the twenty-first century will undoubtedly center on the importance of intangible and perhaps obscure factors in shaping a technological world and civilization worth living in. Persons living in all corners of the planet are experiencing heightened tension and intense personal anxiety. Many of us worry that the human race has lost its way and is on a collision course with doom. "What some observers perceive as the contemporary crisis of society, east and west, is said to be due not so much to material constraints, lack of necessary techniques, or lack of information, but rather to a shortage of virtue" (Swearengen and Woodhouse, 2001, p. 16). As we learned earlier in the discussion of the ethics and values revered by various cultural groups, a good and fulfilling life does not revolve solely around more possessions, or better technologies, or even more extensive knowledge. In the end, personal character, public harmony, social ethics, and moral qualities must be interwoven with our technologically dependent, economic well-being to sustain a venerable civilization.

To conclude this discussion, let us review the intriguing principle of *kenosis*, a Greek word for self-emptying, but a term that also has meaning in theology. South African cosmologist George F. R. Ellis proposes that:

> The foundational line of true ethical behavior, its main guiding principle valid across all times and cultures, is the degree of freedom from self-centeredness of thought and behavior,

> and willingness to freely give up one's own self-interest on behalf of others . . . there is an ethical underpinning to the universe as well as a physical one . . . a benevolent Creator arranged things just so intelligent beings could experience kenosis. (Cited in Gibbs, 1995, p. 55)

As we in the technology education profession continue to devise ways for our students to learn about the role of ethics in the development and use of technology in their world, we must move beyond a United States' perspective. Social concepts are complex and often vague, and ethical issues are challenging to deal with. We have learned that some of the salient themes for ethical rules include integrity, responsibility, fairness, honesty, caring, protection from harm, disclosure, and so forth. Our next accomplishment will feature an understanding of how cultures other than our own apply meaning and value to these themes in activities related to the process of scientific discovery and technological innovation.

REFLECTION QUESTIONS

1. What role did ethics and values play in the founding of the United States?
2. What limits should be placed on the display of religious documents in government buildings in the United States?
3. How does the process of immigration to the United States in the twenty-first century compare to that of the nineteenth century? Should immigrants be encouraged to assimilate mainstream cultural values or to preserve their own cultural values?
4. How would you explain ethics in the United States to someone visiting from another country who inquired about the ethical behavior of government or corporate leaders?
5. If you were living in another country because of your job, how would you be influenced by the ethical standards of a different culture?
6. What ethical standards should be used when businesses owned by United States's citizens are operated in other lands? What if business practices that would be illegal in the United States are acceptable practice in this international environment?
7. How prevalent is the Protestant Work Ethic in the twenty-first century United States?

8. Would you expect there to be an ethic comparable to the Protestant Work Ethic in Asia, Africa, or Latin America? What might be the basis for this ethic?

9. What impact has the Protestant Work Ethic and other ethical belief systems had on the prosperity of the United States?

REFERENCES

Adler, I. (2002). Walking the walk: Can teaching ethics increase business profits? *Business Mexico.* Retrieved September 30, 2002, from http://www.mex-connect/mex_/travel/bzm/bzmadler38.htm

Andrew, T. (1988, May 16). Samsung: South Korea marches to its own drummer. *Forbes,* 84–89.

Bird, S. (2002). Science and technology for the good of society? *Science and Engineering Ethics,* 8(1), 3–4.

Bunch, L. G., Crew, S. R., Hirsch, M. G., & Rubenstein, H. R. (2000). The American presidency: A glorious burden. Washington, DC: Smithsonian Institution Press.

Byron, S. J. (1977, November). The meaning of business ethics. *Business Horizons,* 32.

Cherry, M., & Matsumura, M. (1998). Ten myths about secular humanism. *Free Inquiry Magazine,* 18(1). Retrieved September 30, 2002, from http://www.secularhumanism.org/library/fi/cherry_18_1.01.html

Commission reviews Middle Eastern perceptions of the United States. (2002, May 24). U.S. Department of State. Retrieved September 30, 2002, from http://www.state.gov/r/adcompd/11844pf.htm

Council for Secular Humanism. (2002). *What is secular humanism?* Retrieved October 5, 2002, from http://www.secularhumanism.org/intro/what.html

Cua, A. S. (1992). Confucian ethics. In L. C. Becker & C. B. Becker (Eds.), *Encyclopedia of ethics.* New York: Garland.

Drenth, P. (2002). International science and fair-play practices. *Science and Engineering Ethics,* 8(1), 5–11.

Enderle, G. (2000). Ethical guidelines for the reform of state-owned enterprises in China. In O. E. Williams (Ed.), *Global codes of conduct: An idea whose time has come.* Notre Dame, IN: University of Notre Dame Press.

Furnham, A. (1990). *The protestant work ethic: The psychology of work-related beliefs and behaviours.* London: Routledge.

Gibbs, W. W. (1995, October). Profile: George F. R. Ellis. Thinking globally, acting universally. *Scientific American,* 273, 50, 54–55.

Gluckman, M. (1965). *Politics, law and ritual in tribal society.* Chicago: Aldine.

Gomez, J. E. A. (1993). Mexican corporate culture. *Business Mexico,* 3(8), 8–9.

Goodman, N. (1990). *Doing business in Japan*. Randolph, NJ: Global Dynamics.

Gudkov, L. (2002, February). How are we any worse? Analysis of the roots of anti-Americanism in Russia. *Russia Weekly.* Retrieved October 6, 2002, from http://www.cdi.org/russia/193-7.cfm

Hopkins, W. E. (1997). *Ethical dimensions of diversity.* Thousand Oaks, CA: SAGE.

Hussain, M. (2001, October 19). Anti-Americanism has its roots in U.S. foreign policy. *Inter Press Service.* Retrieved October 6, 2002, from http://www.commondreams.org/views01/1019-05.htm

Kurtz, P. (2002). Secular humanism: A new approach. *Free Inquiry Magazine,* 22(4). Retrieved October 5, 2002, from http://www.secularhumanism.org/library/fi/kurtz_22_4.htm

Maccoby, M., & Terzi, R. (1979). What happened to the work ethic? In W. Hoffman and T. Wyly (Eds.), *The work ethic in business.* Cambridge, MA: O, G & H.

Magesa, L. (1997). *African religion: The moral tradition of abundant life.* Maryknoll, NY: Orbis.

Markert, L. R., & Backer, P. R. (2003). *Contemporary technology: Innovations, issues and perspectives.* Tinley Park, IL: Goodheart Willcox.

McElroy, J. H. (1999). *American beliefs: What keeps a big country and a diverse people united.* Chicago: Ivan R. Dee.

McLaughlin, R. (1990). *Marketing in the United Kingdom.* (Overseas Business Reports, No. 5), Washington, DC: U.S. Department of Commerce, International Trade Administration.

Nash, R. J. (2002). *Real world ethics: Frameworks for educators and human service professionals.* New York: Teachers College Press.

National Science Board. (2000). *Science & engineering indicators—2000.* Arlington, VA: National Science Foundation.

Oates, W. (1971). *Confessions of a workaholic: The facts about work addiction.* New York: World Publishing.

Organization for Economic Cooperation and Development (OECD). (1995). Ethics and corruption. *The management of ethics and conduct in the public service: Mexico.* Retrieved September 30, 2002, from http://www1.oecd.org/puma/ethics/pubs/ethics.mx.htm

Padover, S. K. (1960). *The world of the founding fathers: Their basic ideas on freedom and self-government.* New York: Thomas Yoseloff.

Rokeach, M. (1968). *Beliefs, attitudes and values.* San Francisco: Jossey-Bass.

Singh, J. P., & Hofstede, G. (1990). Managerial culture and work-related values in India. *Organization Studies,* 11(1), 75–106.

Swearengen, J. C., & Woodhouse, E. J. (2001, Spring). Cultural risks of technological innovation: The case of school violence. *IEEE Technology and Society Magazine,* 20(1), 15–28.

Swenson, W. (2000). Raising the ethics bar in a shrinking world. In O. E. Williams (Ed.), *Global codes of conduct: An idea whose time has come.* Notre Dame, IN: University of Notre Dame Press.

Turner, V. W. (1966). Ritual aspects of conflict in African micropolitics. In M. J. Swartz (Ed.), *Political anthropology.* Chicago: Aldine.

U.S. Commission on Immigration Reform (USCIR). (1997). *Becoming an American: Immigration and immigration policy.* Report to Congress. Retrieved October 4, 2002, from http://www.utexas.edu/lbj/uscir/becoming/intro.html

United Nations Department of Economics and Social Affairs Division for Public Economics and Public Administration (UN/DESA/DPEPA). (2001). *Public service ethics in Africa.* New York: United Nations.

Weber, M. (1904, 1905). *The protestant ethic and the spirit of capitalism.* Translated by T. Parsons. New York: Charles Scribner's Sons.

Wolfe, A. (2001). *Moral freedom: The search for virtue in a world of choice.* New York: W. W. Norton.

Words of our American founding fathers. (2002). Retrieved September 30, 2002, from http://www.stephenjaygould.org/ctrl/quotes_founders.html

Design

Section III

STANDARD 3—DESIGN
Technology teacher education program candidates develop an understanding of design within the context of the *Designed World*.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 3. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Explain the importance of design in the human-made world. • Describe the attributes of design. • Analyze the engineering design process and principles.
Performance Indicators:
• Apply the process of troubleshooting, research and development, invention, innovation, and experimentation in developing solutions to a design problem.
Disposition Indicators:
• Investigate the relationship between designing a product and the impact of the product on the environment, economy, and society.

Design and Problem-Solving in Technology Education

Chapter

4

Richard Westberry
Southern Illinois University at McGuire Air Force Base
52nd CTTE Yearbook, 2003

INTRODUCTION

"Design is regarded by many as the core problem-solving process of technological development. It is as fundamental to technology as inquiry is to science and reading is to language arts" (International Technology Education Association [ITEA], 2000, p. 90). The above statement, which is part of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000), emphasizes the importance of using instructional strategies requiring the fundamentals of design as a foundation for teaching technology education. The process of using design for real world problem-solving has long been recognized as a valuable method of instruction and many calls for educational reform have reinforced the need for instruction to include realistic problem-solving as part of the curriculum. Marshall and Tucker (1992) refer to a list of skills needed to address real world problems and demands:

- A high capacity for abstract, conceptual thinking;
- The ability to apply that capacity for abstract thought to complex real-world problems—including problems that involve the use of scientific and technical knowledge—that are nonstandard, full of ambiguities, and have more than one right answer—as jobs change in response to a constantly changing market and the opportunities provided by advancing technology;
- The capacity to function effectively in an environment in which communications skills are vital—in work groups, through the use of computer-based systems that require real mastery of written English, and by reading technical manuals that necessarily presume a high degree of both reading ability and technical competence;

- The ability to work easily and well with others, and the skill required to resolve conflicts that arise with colleagues and assume responsibility for the work that needs to be done without requiring much supervision. (p. 81).

Design and problem-solving are not just the use of the design process for instruction; rather it is a program where students take increasing control of the instructional process by attempting minimally defined and more demanding design problems. The essential idea is that the concept is reinforced by actual application, not by theoretical examples. It has the advantage of engaging the students in problems of interest to the students instead of contrived by the instructor. This is one of the most critical elements of the design and problem-solving process. Researchers such as Sax (1988) have demonstrated that concepts have to be learned in context for them to be successfully applied by students. Assumptions that students can translate concepts and apply them to what they need is not supported by research. The challenge for students is that the problems that are solved must be recognizable as real-world problems. This is true in primary education where problems may involve students' conceptual designs of everyday objects followed by observation of a commercial product and evaluation of design decision-making. It may also be applied at the capstone project for a senior level student responding to an RFP from a commercial manufacturer. The activities in school that are the same as operations performed in business/industry design problems will allow authentic learning to take place. This is supported by the International Technology Education Association (2000), which in the *Standards* document indicated, "Recent research on learning finds that many students learn best in experiential ways—by doing rather than only by seeing or hearing—and the study of technology emphasizes and capitalizes on such active learning" (p. 5). The *Standards* continue by identifying the goal: "The goal is to produce students with a more conceptual understanding of technology and its place in society, who can, thus, grasp and evaluate new bits of technology that they might never have seen before" (ITEA, 2000, p. 4).

PURPOSE

The focus of design and problem-solving as an instructional strategy is the gradual introduction of students to increasingly demanding problems requiring the conception, communication, manufacture, product introduction, and critique of a solution to real world problems. Demands on the student include varying levels of creativity, communications skills, understanding of technological processes, and the impact of technology on society and the environment. The primary advantage of design and problem-solving as an instructional strategy in the technology education classroom is the application of higher-order thinking and learning skills required for successful application of technological skills and abilities. Design and problem-solving activities also provide integration of the different areas of technological study, and often other disciplines, as most problems require the application of concepts from various areas of technology. For example, a new transportation system will also require the use of manufacturing processes which may be existing or new processes.

DEFINITION OF DESIGN AND PROBLEM-SOLVING

Design and problem-solving is a powerful instructional strategy that enables students to develop higher-order thinking skills and greater abilities to address real world problems. The strength of this approach is that it is not just a theoretical structure for instruction, nor a system of forcing the student to confront all of the learning problems in a task. The primary purpose of design and problem-solving is to use a structured program of decreasing instructor guidance to shift the focus of content delivery from the instructor to the student. The mechanism for this process is the creation and implementation of solutions to actual problems similar to the problems faced by design professionals in the real world. This approach is reinforced by the ITEA (2000) *Standards* which state, "One of the great benefits of learning about technology is also learning to do technology, that is, to carry out in the laboratory-classroom many of the processes that underlie the development of technology in the real world" (p. 5).

COMPONENTS OF THE INSTRUCTIONAL STRATEGY

Design and Problem-Solving

One of the most important concepts of design and problem-solving is an understanding that design skills and problem-solving skills, while interconnected in the process, are distinct and separate. Design does not necessarily involve problem-solving. For example, most aesthetic designs do not address a "problem." They follow the same steps as other design work and can be evaluated in terms of execution of the steps of design, but they are not created to address a perceived problem. Conversely, problem-solving can certainly exist without any design process and commonly occurs in many daily situations. Dealing with an untied shoe is certainly a problem and can be formally defined as a problem using a standard definition, but an untied shoe typically would not require a process of design to solve.

To help understand problem-solving, Pahl and Beitz (1996) defined a problem as having three characteristics: "An undesirable initial state, i.e. an unsatisfactory situation exists; a desirable goal state, i.e. realizing a satisfactory situation; and obstacles that prevent a transformation from the undesirable initial state to desirable goal state at a particular point in time" (p. 47).

Thus, Pahl and Beitz are stating the critical aspects of a problem. The first aspect is that a problem represents an undesirable initial state; some part of the situation is not working. Secondly, a definable situation replaces the initial situation that is satisfactory; in other words, the situation could be better. Finally, changing the first situation to the second faces impediments. Using these parameters as a structure, the process of problem-solving then becomes a matter of choice: defining a goal state that realizes a satisfactory condition by removing or resolving the obstacles preventing the transformation from taking place or initiating the process of change to the desired state.

It should be apparent to anyone teaching in an area requiring original problem-solving that the most critical aspect is the creation of a problem definition. This step is critical for a number of reasons. First, the problem definition must clearly define the parameters of the problem, thus limiting the goals to specific areas. The process of clearly defining the problem is critical to design and problem-solving as it keeps the students from attacking designs unachievable under the constraints of the typical school. The second reason for this step being so important is that it allows the problem to be attacked in a structured methodical manner. This is not to suggest that problem-solving is a linear activity, quite the opposite. In most cases, although taught as a series of steps, problem-solving happens in a variety of ways. In many cases, problems are solved in an intuitive manner. The critical part for the teacher is not to discourage intuitive approaches, as long as they are documented.

The most important benefit of a structured problem definition is the necessity of students to build an accurate mental model of the problem. This process is critical to the solution of the problem as many failures in problem-solving are not necessarily a failure in the execution of a problem-solving strategy, but a failure in the conception of the problem. Take, for example, a transportation problem executed by undergraduate students in a technology education class. This problem required them to design a transportation device to perform a series of tasks related to carrying cargo. One particular group of students created a vehicle which used hot melt adhesive to hold an electric motor in place. Conceptually the problem-solving strategy appeared logical but the forces involved were greater than the adhesive could hold, resulting in a vehicle that did not work. This represented a failure to observe or measure the forces required to solve the problem, not in the execution of the problem-solving strategy. Thus, developing the correct mental model of the problem beforehand becomes an extremely powerful problem-solving strategy.

The process of design is different from problem-solving although it has some similarities in the structures of thought associated with problem-solving. Design is typically taught as a linear process, each step following the prior. However, research done by Pirolli (1992) shows that the process of design is dependent on diverse factors, including the type of design, the person doing the design, and the social, political and intellectual situation of the design process. Understanding these factors means that a process capable of producing satisfactory results for one design might not serve another design at all.

Many models for the process of design can be considered, ranging from some models containing thirty steps to those containing only four. One model having a great deal of acceptance has been developed by Pahl and Beitz (1996), which defined four steps in the design process:

- Product planning and clarification—defining the design task.
- Conceptual design—collecting ideas and potential solutions.
- Embodiment design—creating and troubleshooting the final design.
- Detail design—completing the details such as production methods, final form design or marketing.

Although insufficient space does not allow discussion of all the aspects of this process, a couple of salient areas should be addressed. These are areas of primary importance for teaching design. The first important aspect is an emphasis on product clarification. The importance of students clarifying what they perceive as the problem cannot be emphasized enough. If the students cannot clarify the problem, they cannot hope to complete a successful design solution.

The second aspect of design is the conceptual design process. Imbedded in this stage is a process called ideation, or, the formal conceptualizing of design ideas. The ideation process is formal and should require students to submit a written procedure of the exact process used for the specific design they are working towards. A multitude of processes can be used for ideation, such as a knowledge box, a morphological matrix, or analysis of existing systems. Any design text will have a variety of ideation techniques. Figures 4-1. Knowledge Box and 4-2. Morphological Matrix of Simple Transportation Design show ideation processes commonly used for conceptual design.

Figure 4-1. A Knowledge Box is used to graphically combine "knowns and unknowns" of a potential conceptual design. Knowledge boxes are easy for students to understand and have the advantage of graphically illustrating potential tasks related to the necessary processes for finalizing a conceptual design. For example, if a large number of items are listed as "know you don't know," this would demonstrate a need for research into these areas. The typical characteristic of a knowledge box is that initially the top row has most of the information and the bottom row gets filled in as time progresses.

Known	Unknown
Know you know	Know you don't know
Don't know you know	Don't know you don't know

Figure 4–1 Knowledge Box.

Figure 4-2 Morphological Matrix of Simple Transportation Design is a process is used to rapidly distinguish between viable approaches and designs with a low chance of success. The different axes of the matrix represent the initial components of a conceptual design. Morphological matrices lend themselves to systems designs, requiring the interaction of different parts in a design. Systems designs are extremely common in technology. These matrices allow different parts of the system to be rapidly compared for compatibility. The advantage of this type of comparison is that it helps to prevent the creation of design concepts that are created in isolation, by comparing them as interactive parts in a larger system.

	Gear Train	Belt Drive	Chain Drive	Fluid Power
Electric motor				
Fluid power				
Stored energy				

Figure 4–2 Morphological Matrix of Simple Transportation Design.

When analyzed, the matrix graphically helps to show the relationships between different transportation components, such as the relationship between the electric motor and belt drives, or the chain drives and fluid power, etc. The boxes that are shaded represent unknown relationships and, thus, may develop into potential problems for a particular design.

All of these techniques have one thing in common: they force the student to perform meta-design processes, mentally constructing and analyzing the entire design. Meta-design is an extremely powerful process of visualizing a design. It is a learned process; the more it is done, the better it is performed. Encouraging students to apply meta-design processes saves them time, material, effort, and stress. Meta-design, like any other metacognitive process, is also a powerful learning technique.

Development of Production Capabilities

At some point, a theoretical design must become the actual or final design. In most situations this requires attention to some type of production capability to meet the intent of the design. This may mean using materials in a manufacturing process, using multimedia to produce communicative products, or using a variety of other processes. While production capability is an important part of the design process, a great temptation to de-emphasize it occurs since it is easy for teachers and students to become so involved with the design processes that they lose sight of the ultimate objective.

Production capabilities are part of most technology education curriculum designs. The most important point when thinking about the production capabilities is to de-emphasize the specifics of production as formal coursework and to concentrate on conceptual materials for the majority of students. Students learn specific production information on a need-to-know basis. This need-to-know basis is determined by the specific design and production approaches decided on by the students. The reason why this approach is so effective is that students become motivated to learn about specific production processes for their own purposes. As a teacher, this removes the burden of creating a motivation for the student to learn the material, one of the more difficult aspects of successful teaching.

It is not necessary to delve into production in great depth as most of the curriculum used in technology education programs covers production in great detail, but several aspects of production do become important. First, since students have the freedom to choose the type of production process used for their designs, they must be able to make intelligent decisions about the most appropriate production process for a given design. This means that a broad fundamental understanding of the advantages and disadvantages of production processes becomes important. Secondly, most designs will require multiple production processes. Thus, students must understand how multiple production processes work together. This is also part of the meta-design process as described earlier. In this circumstance the student must visualize the entire process of production and the difficult process of sequencing. The difficulty in this process is not knowing the proper sequences of production processes ranging from the initial documents to a finished product (design detail). Finally, it is important that students do the entire design; thus they must construct solutions rather than just theorize about them. The ITEA *Standards* are very clear about incorporating aspects of model and object construction as part of the education of a technologically literate person: "Students in grades K-2 should be able to . . . . Build or construct an object using the design process" (p. 116), and "Students in grades 3-5 should be able to…Test and evaluate the solutions for the design problem" (p. 118), and "Students in grades 9-12 should be able to . . . Evaluate the design solutions using conceptual, physical, and mathematical models" (ITEA, 2000, p. 123).

The essence of this process is the requirement that students must think through the design planning, think through the conceptual design, execute the embodiment of the design, and execute the details of the design. This process requires both cognitive and psycho-motor skills, as required in actual design problems.

Development of Creativity and Innovation as it Relates to Design and Problem-Solving

Perhaps the best description of the development of creativity and innovation is giving students the license to approach the improbable. This is critical in the understanding of design and problem-solving. The essence of the design process is that students own the product of a design problem and the teacher owns the process. The teacher must not dictate the method of obtaining the product as part of an assignment. If students can apply an alternative approach—and hopefully students will try approaches unforeseen by the teacher—they must also be evaluated on the quality and originality of the design process as opposed to just a final product. The best method of teaching creativity is to create an atmosphere of acceptance and the reassurance that students will not be punished for trying unusual designs. The focus should be placed on the process of design and execution rather than the product or the tangible result of the design. This does not suggest that the teacher discount success or failure of the design to meet the design specification, as it certainly is an important measure of success. A student demonstrating a good understanding of a design specification by trying an unsuccessful new approach is still a successful student. It is also important to keep in mind that the purpose of using design as an instructional strategies is to get students to learn about technology, not to create a specific product.

Influences on Design and Problem-Solving

Students need to understand that design is not a black-and-white process and that it does not happen in a vacuum. One of the most difficult concepts for students applying design and problem-solving is an understanding that their answers are not right or wrong, only solutions that meet the design specification elegantly. One of the major tasks in understanding this concept is an acceptance that the social and political structures of the world have a major influence on design decisions. *The Standards for Technological Literacy: Content for the Study of Technology,* (ITEA, 2000) discuss this in middle school design problems. Designs certainly can contain elements of social and attitudinal components, such as asking students to report on current attitudes toward processes or materials choices. Because social and attitudinal components of design also have a place at the secondary and post-secondary levels of education, it is important to connect the designs developed in a high school technology education course with the expected demands of the real world. This reinforces Chapter 4 of *The Standards for Technological Literacy: Content for the Study of Technology,* (ITEA, 2000) in which the issues of social, political and other conflicts that have an effect on design are discussed. This particular aspect of student learning is very important in the process of understanding design trends and futuring as related to design. It is very common for students to assume that the best technology will necessarily become the most popular. It is also important for them to understand that social, political and attitudinal pressures will have a significant effect on the acceptance of design solutions. It is also important for students to realize what pressures surround their own designs and how, although they may feel justified in the production of controversial design approaches, real world pressures may limit the acceptability of specific designs.

Design decisions typically involve individual, family, economic, social, ethical and political issues as well. Often these issues lead to conflicting solutions. Based upon how these issues impact the design, certain design solutions should not be developed (ITEA, 2000). Students should be reminded that the changes occurring in society may be a major influence on the acceptability of new designs. Take, for example, the social changes represented by the assassination of John F. Kennedy, the explosion of the Space Shuttle, the terrorists attacks on the Pentagon and the World Trade Center. All of these events have had a major effect on the outlook and attitudes of the general public and, thus, may have made certain designs desirable and others unmarketable.

APPLICATION OF DESIGN AND PROBLEM-SOLVING

Many projects promote the principles of design and problem-solving in the technology education classroom. One such program is called Design and Technology. Design and Technology is a design and problem-solving strategy implemented internationally in pre K-12 programs. It is a part of the nationally mandated curriculum in the United Kingdom (Qualifications and Curriculum Authority, 2000) and is included in both the Dutch national curriculum and in most of the German regional curricula.

Design and problem-solving programs in the United States are typically part of middle and/or high school technology curriculum. It may be part of any existing manufacturing, communications, construction, or transportation curriculum. In addition, parts of the philosophy of the Design and Technology program have been included informally in many of the technology education courses for many years.

Assessment of students in the Design and Technology program follows the same emphasis as that of real world design applications. The most important aspect of assessment is to examine the process of design and the success of students in documenting the process. It is important to remember that the process is more important than the end product. Thus, the focus on the process should consider the following:

- The quality of the conceptual design and analysis of the design specification.
- The ability of the student to adapt to the problems associated with the design.
- The quality and elegance of the design, elegance in this case means simplicity of design and an appearance of quality.
- The extent to which the intended design meets the design specification.
- The ability of the student to communicate the above to someone else.

RELATIONSHIP TO STANDARDS FOR TECHNOLOGICAL LITERACY

Design and problem-solving instructional strategy reflects the intent of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) with incredible accuracy. In fact, chapter 5 of the *Standards* addresses the importance of design and problem-solving as an integral part of technology education. In addition, many of the most important attributes of Design and Technology curriculum mentioned earlier relate to the *Standards.* For example, concepts such as having more the one solution or solutions being unclear also parallel the *Standards.*

Middle School Design and Problem-Solving

A typical middle school design and problem-solving activity is not a contrived teacher-based activity. It is critical that the students evaluate the problem and develop problem-solving approaches encompassing the limitations of the environment. One successful strategy is to involve students in the discovery aspects of the problem because design problems must have importance to the student, not the instructor. It is advisable to recognize aspects of a middle school student environment and the level of importance attached to these aspects to guide students into potential areas of interest. Examples of activities at this level include the redesign of beverage containers, the design of a reusable grocery bag, graphic design of anti-smoking posters and videos, and other problems from the real world of the students.

At the middle school level, the emphasis is on clearly defined problems that lend themselves to technology-based solutions. However, an instructor must resist the urge to select a problem for students. Although easier for the teacher from a management perspective, the student must own the problem. This ownership will help to insure that they attack the problem realistically and do not feel that they must find a right or wrong solution. The key to middle school activities is not in the limitation of the problem, it is in directing the student to attack a manageable aspect of the problem.

Consider the example of using the problem of beverage containers. Rather than students trying to address the entire spectrum of beverage container design, direct a group of students towards the design of labels that would appeal to different demographic groups or the creation of a pouring spout to reducing spilling. Each of these can be effectively used as a design problem.

High School Design and Problem-Solving

High school activities range from the continuation of clearly defined technology based designs to social/political/behavioral community based problems without any clear or easily defined solution. The entry-level high school designs are intended to reinforce the basic design approaches used in the middle school, by using new materials and technologies.

The higher levels of any design and problem-solving strategy require students to define the problem; defend their conclusions about the problem; develop and present the conceptual approach to the design solution; construct, test and refine their proposed solution; and report the results. This process requires a great deal of self-discipline on the part of the students and the ability to work independently, solving small problems by themselves. Examples of this level of design might include modification of wheelchairs for increased mobility on difficult terrain, creation of new designs for cosmetic containers in response to a commercial RFP, new design for headlights at day and night on automobiles.

At the high school level, design and problem-solving students create solutions to problems that may not be solved with technology alone. This may mean proposing changes in behavior in the population impacted by the problem or it may require a legislative solution proposed as part of the solution developed by the student. The major emphasis is on problems that are student defined and require more than just redesign. The major change in higher-level design problems is the introduction of messy problems that do not have an easy, technology-based solution. This requires students to more clearly define the particulars of the problem being addressed and to propose solutions based on the real-world constraints specific to the problem. Students, thus, will be required to creatively apply problem-solving strategies, instead of just replicating existing approaches. They may also need to solve both technology based problems along with considerations of the attitudinal roadblocks. In addition, they may have to creatively utilize under-funded and under-supplied resources, just like in real life.

One of the best strategies for design and problem-solving at the secondary level is to rely on models for many of the proposed solutions. It may not be possible for students to acquire, modify, and test a full-size and full-price wheelchair. It is certainly possible to acquire or fabricate a specific part from a wheelchair or to fabricate a scale model of a wheelchair. This model can then be used to test the concepts of the proposed solution.

Undergraduate Design and Problem-Solving

Design and problem-solving is an ideal instructional strategy for undergraduate students in technology programs. It encourages integrative activities and has an intrinsic appeal for most students. Technology students in college have a particular affinity for design and problem-solving assignments as it gives them an opportunity to integrate the information they have learned in other classes.

One approach is to give undergraduate students design assignments related to their expectations as they enter the workforce. For example, one of the assignments could be to evaluate and design solutions for common power tool accidents. This particular assignment has many advantages from an instructional standpoint. First, it requires very little motivation for students as they can easily picture themselves having to deal with potential accidents in a laboratory. The second advantage is that it allows them to become better educated in the area of safety in a laboratory and hopefully become more aware of accident prevention strategies. The final advantage is that it allows the student to verify the safety information they had received in other classes by researching the data themselves and discovering the mistakes made by colleagues in the field.

Design and problem-solving can also be used as a comprehensive instructional strategy. It provides a method of integrating all areas of technology, similar to the demands of the real world. Design and problem-solving can work well as a capstone experience. If a program applies the fundamentals of technology in lower-level classes, providing the foundation of technological literacy and abilities, design and problem-solving-based courses are an excellent way to integrate the foundational knowledge and skills, highly motivational for students, and an excellent example of real-world application.

SUMMARY

Design and problem-solving as an instructional strategy can align the technology education curriculum with the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). It also represents a change in the way technology education should be taught. Technology teachers realize that technology is a major discipline and that all content areas can draw on technology. Furthermore, design and problem-solving is the application of this entire discipline as an integrated subject into other disciplines and to the challenges of the real world. It is not enough to just know about technology. Technology and its application can best be taught using the processes and procedures described in design and problem-solving as an instructional strategy.

DISCUSSION QUESTIONS

1. Why is it important to include design and problem-solving instructional strategies in the technology classroom?
2. Which is more important for students, the design process or the final product being designed, and why?

3. Why is it important in the design process to include not only the technological solution, but also the requirement that the solution must fit into society?
4. What are the important characteristics of an accepted design process and why are they important?

REFERENCES

International Technology Education Association (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: ITEA

Londonom, E. A. and Botero, A. L. (2000). *A cognitive approach for technology education.* Paper presented at ICTE 2000 at Technical University Braunschweig, Germany.

Marshall, R. and Tucker, M. (1992). *Thinking for a living.* New York: Harper and Collins.

McLaren, S. (2000). *Education for technological capability: Exploring everyday items.* Paper presented at ICTE 2000 at Technical University Braunschweig, Germany

Pahl, G. and Beitz, W. (1996). *Engineering design.* (Ken Wallace, Lucienne Blessing and Frank Bauert Trans.) New York: Springer.

Pirolli, Peter (1992) *Knowledge and Processes in Design.* Berkeley: California University (ERIC Document Reproduction Service ED 354 252)

Qualifications and Curriculum Authority. (2000). *Design and technology.* London: author.

Saxe, G. B. (1988). Candy selling and math learning. *Educational Researcher* 17 (6) 14-21.

Design—The Creative Soul of Technology

Chapter 5

James R. McCracken
Bemidji State University
Bemidji, Minnesota
49th CTTE Yearbook, 2000

The small plume of dust settles slowly in the ravine. Sounds of hoof beats and shouting voices have been replaced with the sound of wind passing through the grass. A band of ancient hunters thread their way down to the bottom of a steep, rocky ravine to survey their success. They examine the carcasses of deer they have chased over the cliff.

The animals are hauled up to the plateau and loaded onto skids fashioned from sapling poles lashed together with sinew. The hunters drag the quarry back to the encampment. Living quarters for this band of people are small huts constructed from a framework of sapling branches and poles, and covered with tanned hides of animals from earlier hunts.

Collectively, band members begin the task of processing their latest bounty. A chipped rock-cutting tool is used to skin the carcass. Once skinned, the hides will be scraped with other rock tools, and stretched on wooden racks for drying. Tanned hides are fashioned into crude apparel and used to build or repair huts.

Meat is cut with sharp edged bone tools. Surplus meat is dried in the sun on wooden tripods, or cut into small pieces and mixed with other foodstuffs. This mixture is stored in reed baskets. Bones are scraped clean of meat and fashioned into tools with sharpening stones. Teeth and fur are formed into jewelry, toys, or cultural and social ornaments.

The creation of tools and other devices signifies a defining moment in the emergence of technology. Technology may be thought of as people using knowledge and resources to create objects to meet their needs. The manner in which these people lived and hunted was made possible by the use of these items. Weapons greatly increased their hunting success. Shelter greatly increased their comfort level.

Technology is evidenced by all of the things humans have created throughout history. Look around. The chair you are sitting in, the light used for reading, the CD player, and the clothes that you are wearing are all examples of technology.

By itself, the historical importance of human beings using technology is profound. However, there is another equally profound milestone of human civilization intertwined with the evolution of technology. That milestone is the ability to design. Design signifies the human capacity to consciously make a connection between recognizing a need and developing a solution to meet that need.

Design can be described as the process of creating something useful. It brings a sense of order where before there was only the randomness of nature. Design is a blend and balance of form and function. Function serves as the operational component of design. It represents the purpose of which the designed item does what it is supposed to do, such as the ability of a radio to receive and broadcast a signal.

However, design would be incomplete with only the element of function. Design also includes form, which may be represented by shape, mass, color, and texture. Evidence of form can be seen in the contours of an automobile, or the pattern of a shirt fabric. It represents artistic and esthetic values expressed through lines and surfaces.

Design is an edifice of human achievement, and reflects social and cultural values. This can be illustrated by architecture. As a workplace, an office building functions well by providing privacy, light, heat, and protection from the elements. However, a skyscraper of breathtaking angular lines, reflective glass, and granite facades serve as a symbol of a progressive company or community meant to inspire both workers and passersby.

Design is initiated as a mental process. It its infancy, it is invisible to the eye, yet readily evident with an end product. A solution for a skyscraper begins as a dream in the mind of the architect. Technology is typically manifested in physical objects. The building is only a set of plans on paper until a builder transforms the dream into dimensional reality with bricks and mortar.

In this way, design can be considered the creative soul of technology. As a human soul is to the body, design is to technology. It is important to understand the interdependence and complimentary nature of technology and design. Like the inseparable relationship between body and soul. Technology is incomplete without design. Design cannot be fully appreciated without an understanding of technology. If technology is to be fully understood, then the concepts of design need to be understood.

Technology teachers around the globe have increasingly recognized the importance of this interdependence. Educators from the United Kingdom have identified design as the lens from which to study technology in their school systems. Deemed nationally important, Design Technology is taught to all students, at both the primary and secondary levels. Design has been identified as a major process of technology in the *Technology for All Americans* project in the United States. Recognition of the importance of design as part of technology education is justly deserved.

The essence of design is outlined in the Technological Method Model. In a nutshell, the Model outlines the steps used in creating, or designing a technological device. It traces the creative process through problem definition, identifying possible solutions, selecting, testing, evaluating, and monitoring the implementation of a solution. To understand design, students must understand the Technological Method.

Design provides a unique approach to studying technology. As a common denominator, it is equally present in designing a mass transit system, consumer electronics, or new biotechnology products. Design is connected to environmental, social, and economic factors. Cutting across technology with a universal perspective, it is also timeless. Its origins are in the dawn of civilization, as illustrated by the band of hunters described earlier. It will be here as long as humans face the challenges of the future. Design can be a delivery mode to teach any type of technology.

Imagine a consumer shopping for a new digital camera with an understanding of design and technology. Browsing through the store display, they are confronted with a dizzying array of choices. Holding a camera in their hands, they evaluate the ergonomic features such as button position and operation. They ask functional questions about the flash and adjusting the image. The sales person explains the warranty, service, and expected product life span. The consumer is able to make an educated decision on purchasing a camera.

An appreciation of design goes far beyond consumerism. Design is the lifeblood of economic security for a company. Nothing more poignantly illustrates this than the 3M Corporation, a company with a worldwide reputation for innovation in product development. With corporate goals of maintaining market share, a constant stream of new products needs to be designed. The philosophy of 3M management is that 30% of earnings each year must come from technological development in the last five years.

Given the fact that it typically takes hundreds of initial ideas to ultimately come up with one idea that actually has market potential, it is mind boggling to consider how many initial ideas 3M employees generate. This example speaks to the insatiable appetite that companies have for employees with a design flair. It is important for all of their employees, not just engineers, to have an eye for design.

Think of design from the perspective of a learner. Design naturally fosters higher order thinking, inquiry, and problem solving. As students tackle a design based learning activity, they access a learning environment without horizons. They learn from an inquiry perspective the nature of searching out solutions. They are not limited in creative vision by the blinders of only certain materials or processes.

Teachers must understand the nature of design too if they are to optimize learning through design. Design is not a one shot process. If it isn't recognized as an ongoing process, the educational value will be shortchanged. Learning stops when the design project stops. Too often learning activities such as bridge building don't take advantage of repeated testing, redesign, and refinement.

Imagine flying over a wind swept prairie similar to the one inhabited by the ancient band of hunters. You have returned to the present from prehistoric times. Zooming down, you find yourself in the cockpit of a racecar. Low to the ground, the countryside glides by. Not a typical racer built for speed, it is a vehicle built for achieving maximum fuel mileage. What else makes this racer unique is that it was not built by professional engineers, but by a team of high school students. Some of the vehicles can achieve a remarkable mileage rating of over 700 mpg.

The racecar epitomizes the use of design in technology classes. The basic premise of the design problem is simple. Design and build a vehicle powered by a standard three horse gasoline engine to safely transport one human being with the highest miles per gallon possible. This design challenge is an activity both rich in educational experience and the breadth of technology it encompasses.

Calling upon the use of the Technological Design Method, students began the design process many months prior to race day. A quick check of the cars shows an eclectic variety of shapes, colors, and mechanical concoctions. No two are alike. Each vehicle represents a philosophy or strategy chosen by the students as the optimum solution.

Students are their own teachers for this activity, with the traditional teacher serving as a facilitator. Students become independent, self-guided learners—the very type of learners society needs to face the ever-changing future. The sequence of design used by modern day technology students parallels the strategies used by the ancient hunters. Both used the creative process to design solutions based on daily needs.

Students quickly learn that design is not a one step process. Just as ancient hunters gained design insight from evaluating each weapon built, so too students test each component of their design, from carburation devices to chassis construction. Failure is common. Subsequent ideas are constantly tweaked to maximize vehicle performance. Reflective of the design process, improvement is constant and incremental.

These students have become intimately familiar with technology through design. They understand the roots of technology, and how it is based in problems of everyday life. They have developed expertise in a multitude of technologies, and the vehicle is testimony to their level of technological literacy. Conceptually, this design problem has provided an invaluable insight into the process of learning and problem solving. They understand the close relationship between design and technology. As individuals, they are well poised for life in the next century that will have an unquenching thirst for new solutions to human needs.

Creativity in the Technologies: a Search for Insight— Inventors and Inventions

Chapter 6

By Paul W. DeVore
36th CTTE Yearbook, 1987

Sub-Topics:

- **Observations by Inventors and Innovators on the Technical Research Process**
- **Observations by Managers on the Technical Research Process**
- **Selected Inventions and Innovations**
- **Summary**

There is much confusion and controversy about creativity in the technologies. One of the reasons is the extremely broad spectrum of activities ranging across basic research and invention to product design, technical research and day-to-day research related to product production and operation. Comprehending the essence of technical research is further clouded by the fact that many of the day-to-day operations in the design and development of products and systems utilize information and techniques that are already known. There is still the myth that new technical means, inventions, innovations and products evolve from science. Many believe that there is a linear progression starting with a scientific theory and progressing through a number of orderly steps, ending in a new device, product or procedure. There is no evidence to support this view. There is considerable evidence that the creative process lacks order, in the sense that the creative process is linear and descends from science.

This is the reason why we should be concerned about technical research and the creative process in the technologies. It is a complex multifaceted process. More knowledge about the behavior of the process will enable us to enhance the process.

Research about the technical research process has become more important today than ever before. Today we live in a complex, interrelated and constantly industrializing world. Those industries and businesses that desire to compete effectively in the global marketplace must invest in research and product development. Concurrently, those countries that desire to remain economically and politically strong must create environments that enhance creativity in the technologies. They must provide for a continual accumulation of the all-important reservoir of knowledge and people from which new technical means are born. The sustainability of social orders is linked to change, not stagnation. Technical research is an important variable in the health of a society and an understanding of the factors that enhance research and creativity is essential.

The purpose of this chapter is to investigate the technical research process from three perspectives: (1) the individual inventor or researcher, (2) the manager of the research process and (3) selected inventions in several fields of technology. The search will be for those factors that are necessary for technical research to be successful or for an invention or new product design to come about.

Today the problem is more complex than ever before. In years past technical research involved such well known items as: James Watt's separate condenser for the steam engine; Joseph Nicephore Niepce's contributions to photography; Christopher L. Sholes' typewriter; Nicolas Otto and the four-stroke cycle internal combustion engine; the Wright Brothers and the aeroplane; Charles Kettering's self-starter for the automobile; Rudolph Diesel and the compression ignition engine; Wallace Carothers and neoprene; Chester Carlson's xerography; and Johannes Croning and shell molding. Other examples are H. F. Hobbs' automobile transmission; the gyrocompass from the work of A. Kaempfe, E. A. Sperry and S. G. Brown; the frequency modulation (FM) radio by Edwin Armstrong; John Harwood and the self-winding wristwatch; mercury dry-cell by Samuel Ruben; Edwin Land and the Polaroid camera; the ballpoint pen from the work of Ladislao and Georg Biro; and tungsten carbide by Karl Schroeter. These and hundreds of other inventions have made significant contributions to the evolution of civilization as we know it and many people are intimately acquainted with these technical developments.

Today the nature of the new technical means is of a different order. Although there appears to be ready acceptance of new technical means, the level of understanding of the way the new technical mean's works or functions is lower. The "working parts" of the technical means of today are less visible, the behavior of the devices or products is more involved and the level of comprehension of the users is less.

The esoteric nature of the current technical means can be illustrated by example. Each year, the editors of *Research and Development* publish a special report which details one hundred of the award-winning products, processes, materials and software that came to the market during the preceding year. The award winners are chosen from more than ten thousand entries. Some examples of award winners for 1985 were: Fourier transformer infrared spectrometer; time-resolved imaging X-ray spectrometer; pulsed helium ionization detector electronics system; high performance liquid chromatography system; high voltage, high frequency power static induction transistors; geometric arithmetic parallel processor; error compensation system for computerized numerically controlled machine tools; electric discharge machine; lead-iron phosphate process for high-level radioactive waste disposal; advanced thermoplastic composites; image-processing system (fluorescent microthermography); pyroelectrochemical extraction process; real-time acoustic robot vision system; magnetic wire position transducer; and high-current monochromatic electron gun, among others (*Research and Development*, October 1985).

The above commercial products came from a wide range of research and development (R&D) laboratories which are private, governmental and university. some are well known laboratories, while others are less well known. Examples are Argonne National Laboratory; Beckman Instruments; Corning Glass Works; Dowell-Schlumberger, Inc.; GTE Laboratories; Isco, Inc.; University of Michigan; National Bureau of Standards; Skantels Corporation; Union Carbide and Zeiss, Carl, Inc.

The products, materials and processes created in the R & D laboratories listed above are the outcomes, the manifestations, of the creative potential of the human mind. Some laboratories and some researchers have been more successful than others. What are the factors that make a difference? There are several ways to pursue this question. One way is to find out what creative people say about the process and to examine given inventions and innovations in detail. Another way is to find out what mangers of the process believe to be critical factors. In the sections which follow, the process will be examined from the perspective of the (1) inventors and innovators, (2) mangers of technical research and (3) specific inventions and innovations.

OBSERVATIONS BY INVENTORS AND INNOVATORS ON THE TECHNICAL RESEARCH PROCESS

One of the most significant technical developments that provides the base for the current communication and information evolution was the creation, by Jack St. Clair Kilby of Texas Instruments, of the integrated circuit; patent number 3,138,743—Miniaturized Electronic Circuits. Kilby, in reflecting on himself and his research, volunteered "that is basically what I have always wanted to do, to solve technical problems. It is quite satisfying, extremely satisfying, to go through the process and find a solution that works" (Reid, p. 34). Reid, in his review of Kilby's work, noted also that Kilby learned exactly how the realities of the manufacturing process restricted the complexity of transistorized circuitry (Reid, p. 34).

Richard R. Walton (1985), independent inventor and researcher of Boston, Massachusetts, pioneered the creation of shrinkage control processes for the textile industry. He believes that corporate researchers often play it safe and try for small improvements in their company's existing products rather than risk the creation of a new solution (Walton, personal correspondence). Walton has been highly successful in meeting the needs of the textile industries by coming up with new solutions, by going at risk, and by seeing things differently. By doing so he has researched and created an automatic cloth pick-up and feeder to sewing machines, a device for feeding flat goods in laundries, a portable washing machine for developing countries, improved agitators for washing machines, a device for increasing the absorbency of nonwovens and imparting drape, and machines for creping and elasticizing paper. Walton believes that involvement, intensity and the subconscious are critical to problem solving associated with technical research. Many researchers mention the importance of getting away from the problem and letting the subconscious work.

John V. Atanasoff credits his subconscious as being critical in his work. This resulted in the development of the regenerative memory which made a significant contribution to the development of the ENIAC computer by J. Presper Eckert and John W. Manchly. Atanasoff's work at the University of Iowa required an improved calculating instrument to solve linear operational equations, including partial differential system and integral equations. His search was for a "practical solution to practical problems" (Gardner, p. 12).

Walton and Atanasoff each stressed the importance in technical research of identifying the true problem and staying with it. Persistence is the hallmark of success in technical research. Walton (1985) believes that "continuity and determination are more important than anything else." He also stresses the need for the inventor to "isolate everything from his mind except the current project." Walton believes that "almost by definition the independent researcher, innovator or inventor has little regard for social and textbook rules; you can't schedule ideas and something about a large company militates against creativity" (Walton, personal correspondence).

Samuel Ruben, the inventor of the mercuric oxide cell and major contributor to numerous electrochemical developments, found in his research that "the systematic use of existing knowledge is used to solve the unknown" and that "the development of concepts is built upon previous insights in a step-by-step process." For Ruben, his motivation and drive were derived from the realization of industrial needs as was the case with Austin Elmore who said: "Everything I invented was created because it was needed" (Associated press, 1985). Ruben also believes that an inner sense of direction, together with imaginative thinking, is necessary for the actualization of a concept. Self-motivation is also a necessary factor to catalyze the generation of imaginative concepts. Ruben believes the researcher is motivated by the intellectual excitement of the thought process and will resist adverse premature opinions of others who lack imaginative thinking (Ruben, 1981).

The researchers, the problem solvers and the innovators have a number of characteristics as does the process they use. In a special issue of *Varian Associates Magazine* in 1979, the Corporate Communications staff interviewed a number of technical researchers working for Varian in an attempt to gain insight into the process (Himmelman, 1979). One of the primary findings in most research about technical research is stated clearly by Curt Ward of Varian. "Conformists don't invent." From his experience, non-productive researchers or innovators are trapped by "the way it's already been done." The primary problem, though, is the problem. Ward has found that "unless you can define the problem, you'll never get an answer or an invention" (Himmelman, 1979).

Ward and Anderson support the concept of the gestation period mentioned previously. There seems to be an "act of insight." Solutions to problems, according to Ward, "almost always just pop up." Anderson supports this view by saying that "many times the solution just suddenly appears" (Himmelman, 1979).

Mars Hablanian believes that each successful researcher or inventor has a basic ingredient of personality that produces a kind of intellectual delight in solving problems similar to the way Jack Kilby perceived himself. This problem solving interest melds with another characteristic, that of dissatisfaction with doing something the way it has been conventionally done. Al Scott of Varian emphasized the importance of non-conformist, non-conventional factors.

> "In searching for the solution, you see that it won't be solved in conventional ways and look for an unconventional solution . . . . Then, as a result of some other work we were doing, we real-

> ized that if we stopped thinking like tube engineers and started thinking like microwave solid state engineers, we might find the answer. It suddenly occurred to us that if we could print an absorber or resonator on a little ceramic substrate, it would be small enough to fit inside the tube. The resonators would absorb all the power at the oscillation frequency and not interfere with the operating band of the tube." (p. 3)

Other researchers at Varian Associates stressed the importance of motivation, immersion in the problem, the intuitive thought process and, perhaps the most critical variable of all, the realization that there is a problem to be solved.

According to Hablanian, those who are successful researchers are people who usually have a tendency for disorganized thinking. He feels that "there is really no systematic way of stimulating the inventive process" (p. 6), a view held by those who do the research and create the innovations.

There are other views held by those responsible for managing research projects which bring to light one of the central issues concerning technical research in a business and industry. How do you create an environment that enhances the productivity of creative minds?

OBSERVATIONS BY MANAGERS ON THE TECHNICAL RESEARCH PROCESS

The search for a magic solution to managing and controlling the technical research process continues almost universally throughout business and industry that invest in research. Managers without technical research experience, often believe that research can be reduced to a sequential, rational process which, if organized properly, would provide a greater return on investment. Those who have investigated the process of technical research, product development and successful product marketing have found the process to be less than orderly. This is particularly true at the innovation/invention end of the technical research spectrum.

The problem is a critical one for business and industry in a highly competitive international market economy. Various estimates place the contribution of technical change at fifty to sixty percent of U.S. economic growth (Alexander, 1982; Ross, 1986). Yet it has been concluded by numerous authorities that the United States is lagging in research and development.

The President's Commission on Industrial Competitiveness stressed a number of factors believed to be important in enhancing the ability of business and industry in the United States to compete. Among the factors stressed were (1) capital resources, (2) human resources and (3) improved international trade and investment policy. Even though these were important elements,

> …the Commission concluded that the area of *technology* is where we have a current competitive advantage, and where there is the opportunity not only to sustain that advantage but to grow in our leadership (Ross, 1986).

This relationship between creativity in the technologies and economic competitiveness among firms or nations is not new. It is often overlooked by chief executive officers and managers devoid of background and experience in the technologies. There is a tendency to believe that financial management is the panacea and that organization is the secret. There is the belief that if one could just find the "right" organizational structure, the technical research and new product problem would be solved. The reality is that the problem is much more complex. There are many patterns of organization and they vary with the nature of the goals, mission and tasks of technical research. In addition, there are critical interfaces between technical research, product development operations, marketing and sales. Companies such as 3M have recognized the critical nature of these interfaces and have structured their operations to assure linkages among them in what they call a Business Development Unit Organization, BDU (Pearson, 1983).

Roland Schmitt in his analysis of the problems of corporate level research and development believes that the categorization of research into basic versus applied, and market-driven versus technology-driven, have outlived their usefulness. He concluded that "there is no single model appropriate for doing first-rate corporate level R&D," but that there is a way of thinking that makes the different approaches, and their implications, clear (Schmitt, 1985).

Schmitt contrasts two forms of corporate research and development, *generic* and *targeted*. He concludes that:

> The success of a corporate R & D program becomes visible only in the light of its mission and purpose. If the choice is to adopt a *generic,** loosely market-coupled approach, then organization requires a strong discipline orientation and close attention to the number and excellence of contributions to the technical literature. If the choice is to adopt a *targeted,** tightly market-coupled approach, then organization needs a

*Italics added by author.

> project orientation and must link its reward to ultimate business success (Schmitt, 1985).

Patrick E. Haggerty of Texas Instruments, in one of his lectures at the Salzburg Seminar of Multinational Enterprise, stressed the importance of perceiving innovation in a multi-national company as ranging from basic research, what Schmitt calls generic research, to research in the *make* and *market* functions. Haggerty ascribes Texas Instruments' success to their long-range planning system which is TI's system for managing innovation (Haggerty, 1977). In carrying out the long-range planning system Haggerty recognized the importance of the human factor and,

> "set policies in human terms to motivate employees, to permit them to understand, as much as possible, what the company was attempting to do and why, and to establish as closely as possible parallelism between individual and corporate goals" (Fagenbaum,1980).

There are those who question the formal product planning process. Thomas J. Peters' *In Search of Excellence,* and Brian Quinn of Dartmouth's Amos Tuch School of Business Administration maintain that "not a single major product has come from the formal product planning process" (Peters, Summer 1983). Peters, in his study of the innovation process, has concluded that:

> The course of innovation—idea generation, prototype development, contact with initial user, breakthrough to final market—is highly uncertain, to say the least. Moreover, it always will be messy, sloppy, and unpredictable, and this is the important point. It's important because we must learn to design organizations that take into account, explicitly, the irreducible sloppiness of the process and take advantage of it rather than attempt to fight it (Peters, Fall 1983).

Some of the variables in the innovation process that Peters and others have discovered to be important and that challenge conventional wisdom are:

1. New ideas either find champions or the die.
2. Perseverance, not great leaps of insight, is the norm.
3. Placing cooperation and teamwork above all other desirable traits eliminates the product champions, the ones that have the potential to give a company success.
4. Failure is a normal part of the innovation, product development process.

5. Most advances are incremental and cumulative (Peters, Fall 1983).

The focus of R&D efforts is often directed toward the wrong factors. Too often the belief is that structure and organization will bring results and that people are the problem. Too often the product or research focus is forgotten in blind attempts to make the process work by appointing more committees and reorganizing the departments or divisions. The latter only distances those responsible for the management of the process from the real problems and the real people. Peters has concluded that "American management suffers from an excess of the administrative mentality" (*U.S. News and World Report,* July 15, 1985).

Another way of viewing the complex world of technical research is from Freeman's "degree of uncertainty" approach. Freeman proposes that there are qualitative degrees of uncertainty for various types or categories of technical research. Figure 6-1 contains an overview of Freeman's analysis (Freeman, 1974). In reviewing the degrees of uncertainty, it is possible to gain some understanding of the complexity of the technical research paradigm and the many interrelations. Caution is in order since linearity of the process should not be concluded. An interrelated network is more appropriate where there are relationships. Where there are no relationships among any categories of uncertainty, the technical research effort may stand alone at that point in time.

1. True Uncertainty	Fundamental Research Fundamental invention
2. Very high degree of uncertainty	Radical product innovations Radical process innovations outside firm
3. High degree of uncertainty	Major product innovations Radical process innovations in own establishment or system
4. Moderate uncertainty	New "generations" of established products
5. Little uncertainty	Licensed innovation Imitation of product innovations Early adoption of established process
6. Very little uncertainty	New "model" Product differentiation Agency for established product innovation Late adoption of established product innovation in own establishment Minor technical improvements

Figure 6-1: Degree of Uncertainty Associated with Various Types of Innovation. C. Freeman, *The Economics of Industrial Innovation,* p. 226.

In any analysis of technical research it is critical to clearly state exactly what type of research is being discussed. It may be (1) incremental product performance improvements, (2) the creation of new solutions to existing problems or (3) the creation of wholly new approaches to meeting basic human and social needs.

SELECTED INVENTIONS AND INNOVATIONS

In addition to gaining insight into the creative process of technical research from the perspectives of the researchers and mangers, it is possible to obtain an understanding by an analysis of the outcomes of the process: the inventions and products of the creative mind. The nature of the invention or product provides information about the uniqueness and/or complexity of the solution.

The inventions and innovations selected for the purpose of illustrating creativity will represent several fields of technological endeavor. It is not possible to provide a complete case study of each invention or innovation and all the variables related to the "act of insight." This inventor's or researcher's background, education and personality, relation to other preceding research and economic support. All of these variables are important. However, the focus will be on a brief description of each invention or innovation with the interpretation and analysis left to each reader.

Category: Manufacturing

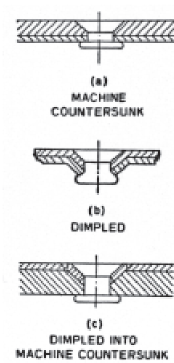

Figure 6-2: Three Basic Types of Flush Riveting from G. Rechton. *Aircraft Riveting Manual,* Addendum I: Riveting Methods, Douglas Aircraft Company, pp. 7, 21 and 26.

Invention or Innovation—Flush Riveting
Inventor or Innovator—Charles Ward Hall
Buffalo, New York, 1935

The development of flush riveting took place primarily in the aircraft industry. As the speed of aircraft increased, the aerodynamic drag of protruding rivets was detrimental to performance of stressed skin aircraft. The obvious answer was to make the rivets flush. As simple as the answer was, it took a long development effort over a considerable period of time. The original work was done by Charles Ward Hall at his Hall Aluminum Aircraft Corporation in Buffalo, New York, in the early 1920s to the 1950s.

The basic stage of development occurred during the second half of the 1930's. Three types of riveting emerged, depending on the sheet thicknesses being riveted: (1) the machine countersunk, (2) the dimpled and (3) the dimpled into machine countersunk. During the early stages of development each aircraft company pursued the problems associated with flush riveting independently. Later standards were adopted and the 100 degree angle for rivet heads was adopted (Vincenti, 1984).

Category: Communication and Information Systems

Invention or Innovation—Sealed alkaline battery structure embodying mercuric oxide and other depolarizers in primary and secondary cells.
Inventor—Samuel Ruben
Portland, Oregon

THEORY OF ZINC/MERCURIC OXIDE SYSTEM		
Material: Zn/KOH_1 ZnO_1 H_20/HgO		
After Solution: Zn/KOH_1 K_2ZnO_{21} H_20/HgO.		
Ionization product of electrolyte: K^++OH^-, $2K^++ZnO_2^{--}$, H^++OH^-.		
	ANODE	**CATHODE**
Reactions when producing electricity:	$Zn–2e^-\rightarrow Zn^{++}$ $Zn^{++}+2OH^-\rightarrow$ $Zn(OH)_2$	$HgO+H_20\rightarrow Hg(OH)_2\rightarrow Hg^{++}$ $+2OH^-$ $Hg^{++} + 2e^- \rightarrow Hg$ $2OH^-$ $+2H+\rightarrow 2$ H_20
Since electrolyte is saturated with ZnO:	$Zn(OH)_2\rightarrow ZnO+H_20$	
Electrode end products:	ZnO	Hg
Since the basic electrode reactions are the oxidation of the $Zn–2e^-\rightarrow Zn^{++}$ and the reduction of the $Hg^{++}+2e^-\rightarrow Hg^o$ at the cathode, and since water appears at both electrodes, there is no significant change in KOH or H_2O concentration. The over-all chemical reaction for producing 2 Faradays per gram mol of anodic zinc and gram mol of cathodic mercuric oxide is: $Zn+HgO\rightarrow ZnO+Hg$		

Figure 6-3: Theory of Zinc/Mercuric Oxide System, from Samuel Ruben's Lecture for the Metropolitan Section of the American Electrochemical Society. February 15, 1966, p. 7.

In 1941, the only commercially available dry cell system for portable communication equipment was the Le Clauche zinc/carbon cell. During World War II, there was an urgent need for transceiver batteries capable of maintain their voltage on loads, retaining their transmission range and not deteriorating in tropical climates. The solution to the problem was the result of research done by Samuel Ruben. He developed a chemical battery embodying (1) an amalgamated zinc anode, (2) zincated potassium hydroxide electrolyte in an absorbent spacer, (3) a barrier in contact with a consolidate depolarizing mercuric oxide and (4) a graphite cathode. All of these elements were assembled and sealed in a steel container. This development enabled the production of miniature cells for electric watches, implanted cardiac pacemakers, hearing aids and hand-held calculators. (Ruben, 1976).

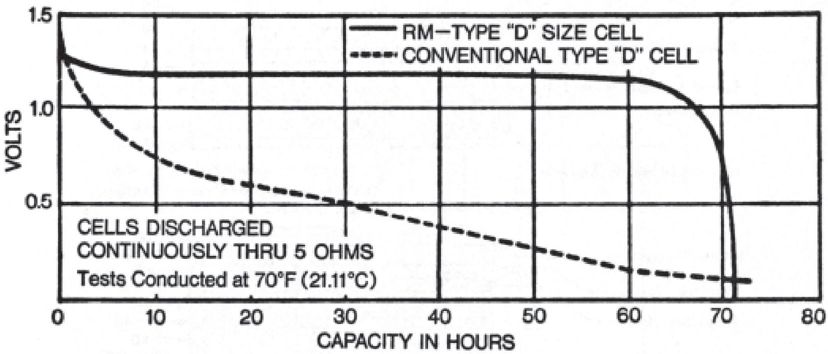

Figure 12-4: Comparison of RM-Type "D" size Cell to Conventional Type "D" Cell Illustrating Maintenance of a Constant Closed Circuit Potential During Discharge, from Samuel Ruben's Lecture for the Metropolitan Section of the American Electrochemical Society. February 15, 1966, p. 8.

Category: Communication and Information Systems

Invention or Innovation—Photographic Product comprising a Rupturable Container Carrying a Photographic Processing Liquid.

Inventor or Innovator—Edwin H. Land

Cambridge, Massachusetts, 1951

The photographic process developed by Edwin H. Land is commonly known as the Polaroid process. It is a product that consists of at least two layers, a photosensitive layer and a base layer for a transfer image and a container that holds a liquid photographic developer. The container is so constructed that it can be ruptured and release its liquid content between the two layers and partially permeate the superimposed base layer and photosensitive layer capable of forming a latent image upon photoexposure and subsequently a visible image upon development.

Land's research was on providing a photographic product comprised of a rupturable, disposable container carrying a photographic processing liquid or solvent. It was constructed to release the liquid content and distribute it uniformly over a photosensitive material to process the exposed photosensitive layer and produce a positive print (Land, Patent No. 2,543,181, 1951).

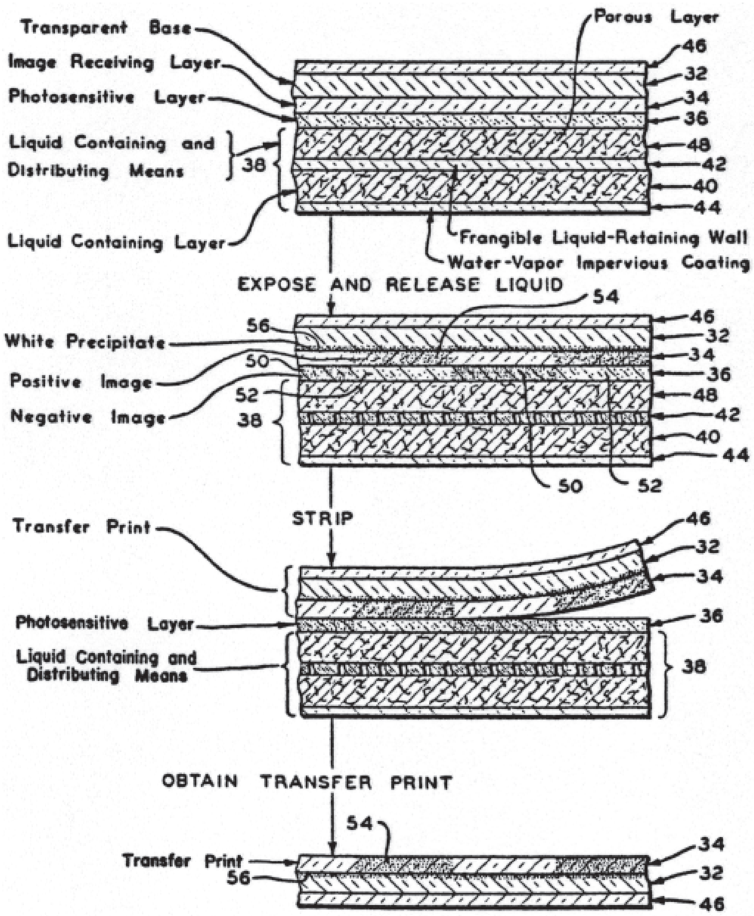

Figure 6-5: Patent Drawing of Rupturable, Disposable Container Carrying a Photographic Processing Liquid that is Released and Distributed Uniformly to Process Exposed Photosensitive Material. Patent Number 2, 543,181, February 27, 1951.

Category: Transportation and Communication and Information Systems

Invention or Innovation—Localizer Antenna System
Inventor or Innovator—Andrew Alford
Cambridge, Massachusetts, 1954

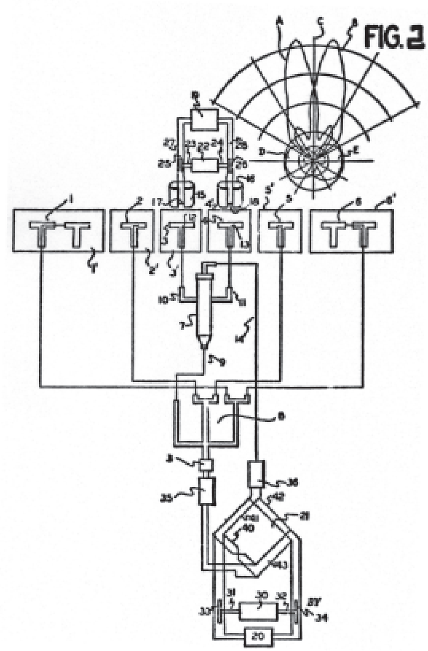

Figure 6-6: Localizer Antenna System Design. Patent Application of Andrew Alford, filed June 22, 1951.

The problem with Andre Alford's invention solved was the instability of the instrument landing system for aircraft and the interference from airport structures. The ground based localizer provides an electronic signal which instruments on the plane receive. The signal plane to the runway in low visibility weather.

The system was developed by Alford at ITT under contract with the Federal Aviation agency. The primary claim of the invention by Alford was:

> "A localizer signaling system for guiding a craft along a course, means for radiating at a main carrier frequency two beam patterns overlapping along the line of the course symmetrically,

means for radiating two comparatively broad intersecting lobe patterns slightly off the main carrier having a comparatively lower magnitude of radiation in the direction of the beams than the beam radiations, the beam and the broad lobe radiation on one side of the course having the same modulating frequency and the beam and broad lobe radiations on the other side of the course also having the same modulation frequency but differing from the first modulation frequency" (U.S. Patent no. 2,683,050).

Invention or Innovation—Transistor Radio developed by Texas Instruments and Regency Radio
Inventors or Innovators—Roger Webster, Paul Davis, Jim Nygaard, Art Evans and Mark Shepherd, Dallas, Texas, 1954

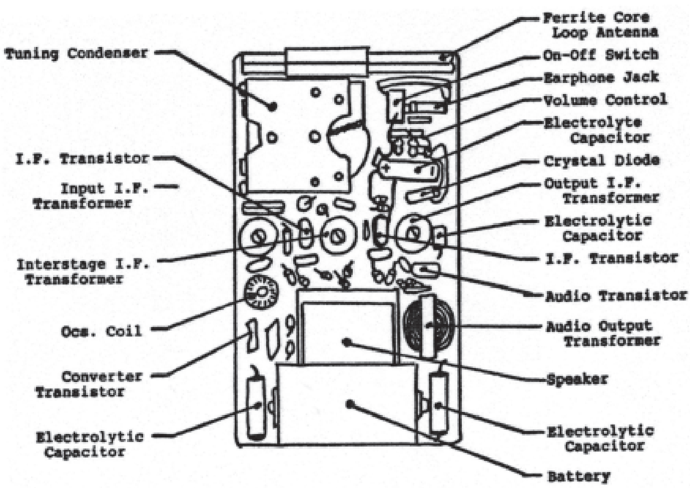

Figure 6-7: The Texas Instruments-Regency Radio of 1954.

The transistor radio was based on the 1947 development of the transistor by Walter Brattain, John Bardeen and William Shockley of Bell laboratories. Texas Instruments (TI) obtained a license to produce transistors in 1951. Gordon Teal of TI developed a reliable mass produced transistor that would sell for $2.50 which became the base for the four germanium transistor Regency radio. The TI research group faced many challenges ranging from reducing the design from eight to four transistors and obtaining miniaturized parts such as a speaker supplied by Jensen sound laboratories (Harris, 1980).

Category: Manufacturing—Materials

Invention or Innovation—Lucalox

Inventor or Innovator—General Electric Research and Development Center Schenectady, New York, 1959

Lucalox is a form of sintered alumina used principally as an envelope in high efficiency discharge lamps that provide a large share of the world's outdoor and factory lighting. The project that led to its invention began in 1954, as the General Electric (GE) R & D Center decided to enlarge its research effort in ceramics by using a more scientific approach to a field that had previously progressed by trial-and-error. Two researchers chose to concentrate on understanding the process of sintering (causing ceramic particles to stick together). They worked with alumina because they could obtain it in reasonably pure form. By 1956, they had developed a way to remove pores from sintered alumina, which greatly improved its ability to transmit light. A representative of GE's Lamp Division who saw a sample of this material became interested in it as an envelope material capable of sustaining the high temperatures of a high temperature discharge lamp. Up to that time such lamps used quartz, which is less temperature resistant than alumina. Single crystals of alumina had been used in experimental lamps but were too expensive for commercial use.

GE introduced the material as a product in 1959. Meanwhile, engineers in the company's Lighting Group were developing a new sodium vapor discharge lamp that took advantage of Lucalox's excellent heat resistance and translucence. The new lamp was announced in December 1962, but sealing and manufacturing problems delayed its introduction until 1965. It has now attained sales of about $120 million a year (Stewart, 1985).

Category: Communication and Information Systems

Invention or Innovation—Ruby Laser Systems

Inventor or Innovator—Theodore H. Maiman Los Angeles, CA, 1961

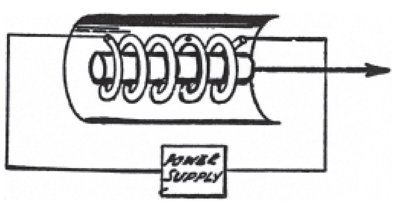

Figure 12-8: Schematic Diagram Illustrating the Embodiment of a Ruby Laser System which Utilizes a Helical gas-filled Flash Tube for Optical Pumping of the Laser Material.

Laser is an acronym for light amplification by stimulated emission of radiation. It is a device capable of generating or amplifying coherent light.

Considerable effort was expended to develop a means of generating or amplifying coherent light. This source of light would open up a vast new region of the electromagnetic spectrum for a multitude of purposes, including communication, measurement and medical procedures.

There are gaseous and solid state lasers. The solid state lasers are superior because they are less complex. The design of a typical ruby laser consists of a cylindrical ruby ($A1_2O_3$doped with CR_2O_3) rod with a reflective coating at each end. This rod is placed coaxially in a helical flash lamp. The green and blue components of the white light are absorbed by the ruby. The red light is emitted and coupled out of the system through a hole in the reflective coating at one end of the rod.

The ruby laser is mechanically stable and can be operated at room temperature without complex vacuum or vapor pressure techniques. It provides light which can be focused with extreme precision (Maiman, 1961).

Category: Communication and Information Systems

Invention or Innovation—Integrated Circuit
Inventor or Innovator—Jack S. Kilby Dallas, Texas, 1964

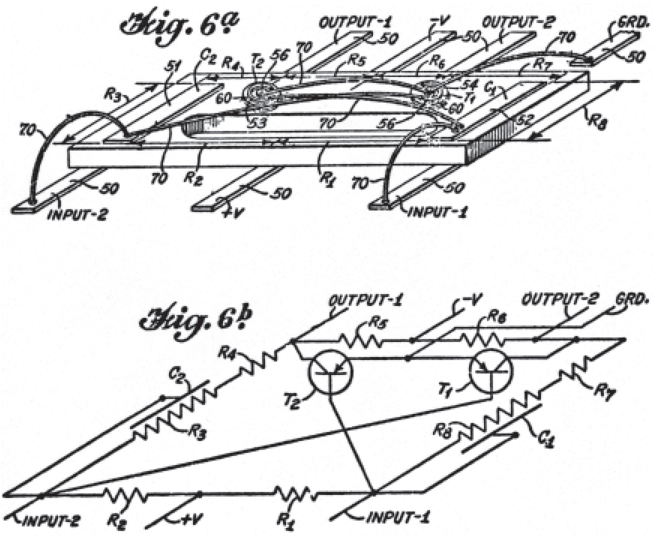

Figure 6-9: Drawing from Patent Application of J. S. Kilby filed February 6, 1959 for Miniaturized Electronic Circuits.

On June 23, 1964, J. S. Kilby was granted patent number 3,138,743 for Miniaturized Electronics Circuits. The integrated circuit is the base of the microelectronics revolution which made possible digital stereo, robotics and long range navigation systems. The integrated circuit solved the problem of the tyranny of numbers in large complex electronic circuits involving hundreds of thousands of components.

Kilby's research was based on the idea of G. W. A. Dummer of Great Britain who suggested in 1952 that "it seems now possible to envisage electronic equipment in a solid block with no connecting wires." Kilby knew that various electronic components like transistors, capacitors, resistors and diodes could be made out of silicon. The idea that revolutionized electronics was "if you could make all the essential parts of a circuit out of one material, you could probably manufacture all of them all at once in a single block" (Reid, 1982).

On July 24, 1958, Kilby sketched in his notebook the idea of an integrated circuit on a single chip and on September 12, 1958, proved the idea valid in a laboratory at Texas Instruments. His idea broke with conventional wisdom and enabled the manufacture of a "novel miniaturized electronic circuit fabricated from a body of semiconductor material containing a different P-N junction wherein all components of the electronic circuit are completely integrated into the body of the semiconductor material" (U.S. Patent No. 3,138,743).

Category: Transportation Systems

Invention or Innovation—Stored energy (Flywheel) propulsion for rapid rail cars
Developer—Garrett AiResearch Corporation, 1974

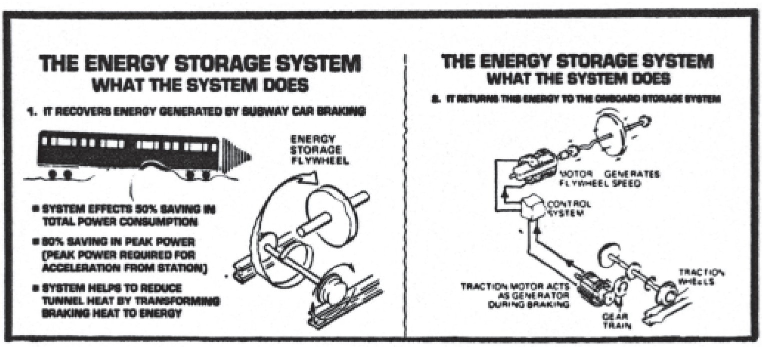

Figure 6-10: The Stored Energy Flywheel System.

The use of the stored energy flywheel in a rapid transit environment was researched by the Garrett AiResearch Corporation using New York City Transit Authority lines. This development has the potential of significantly reducing power consumption, operating costs and the amount of heat released in subway tunnels during the braking cycle.

During the braking process the energy normally dissipated as heat through the resistor grids is used by a motor/generator to increase the speed of the flywheels. During acceleration, the spinning flywheels produce electricity through the motor/generator to assist in driving the traction motors. A DC chopper system is the core of the solid control system.

Category: Construction Systems

Invention or Innovation—Tension Arch Structure
Inventor or Innovator—Samuel G. Bonasso Morgantown, West Virginia, 1984

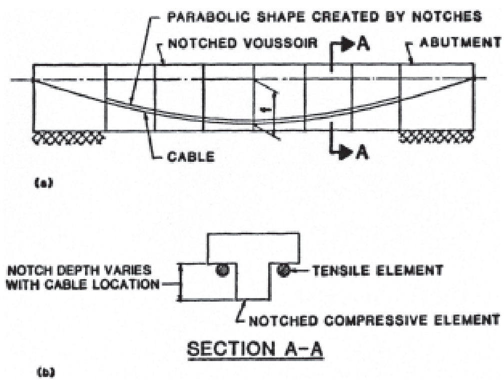

Figure 6-11: Patent Drawing of tension Arch structure Illustrating the Relation of the Cables (21) Stretched and Anchored Between End Supports and the Lateral Compressive Elements Placed over the Cables with Grooves Across the Bottom of the Elements. Patent No. 4,464,803, August 14, 1984.

The tension arch is a structural system for use in bridges, buildings and other structures. The system supports part of its load by tension action and part by arch action. The tension arch represents a unique combination of two elements, the compressive member or arch and the tensile element or suspension structure. The tension arch concept minimizes the use of material at higher overall stress levels. In spans greater than 80' to 100', the system has the potential of achieving system wide weight reduction of 20 percent or more. It is a structure whose geometry is relatively insensitive to a variety of support movements along all three axes (Bonasso, 1984).

Category: Transportation Systems

Invention or Innovation—Oscillatory Motion Apparatus
Inventors or Innovators—Alfred h. Stiller and James E. Smith
Morgantown, West Virginia, 1985

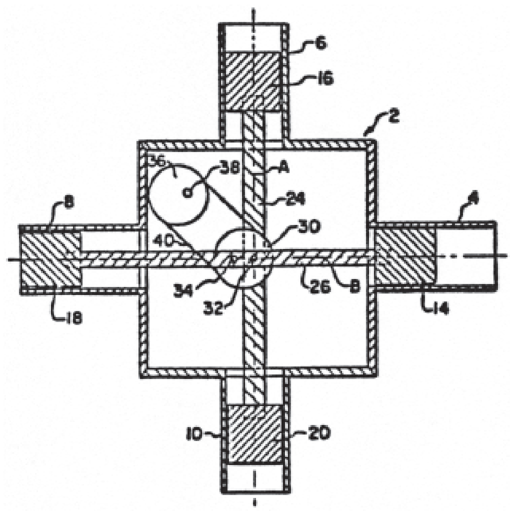

Figure 6-12: Patent Drawing of Oscillatory Motion Apparatus Used as Basis for a New Engine Design Called the Stiller-Smith Engine. European Patent No. 0167149, February 1985.

The Stiller-Smith engine design is based on an oscillatory motion apparatus that has one reciprocating rod oriented perpendicularly to a second reciprocating rod. A first trammel gear (30) is pivotally secured to the first and second rods, A and B. Reciprocation of the rods produces responsive rotation of the trammel gear. This oscillating design may be used in an engine block with two or more pairs of opposed cylinders, each containing pistons adapted for reciprocation.

The engine is compact, 12 inches square and 8 inches deep, and weighs less than 100 pounds. It has a one and one-half to one power to weight ratio. A prototype one liter engine produced 140 plus HP (Nadler, 1985; Stiller and Smith, 1985).

The foregoing brief overview of selected inventions and innovations illustrates the potential that detailed studies of these have for gaining insight into the technical research process. Personal interviews with people who carried out the research can provide an understanding of the human side of the creative venture, including preparation, background and personality factors. Study of the social and cultural context in which the research took place provides information about factors that affect the creative process. The preparation of lineage studies can assist the comprehension of the linkages between and among various technical developments.

The list of technical developments which follows is presented as a resource to those who want to study the technical research process in greater detail.

Variable geometry aircraft	Storm scope
Tetrafluorethylene polymers	Stored programs concept–computers
Nitinol	Pen recorder
Cellophane	Polaroid Camera
LEXAN	Pitot tube
Wood flour	Medical magnetic resonance
NORYL®	Tungsten inert gas welding
Medical magnetic resonance	Super aluminum TM
Computer aided design	MCS linear tacking turntable
Lytegem high-intensity lamp	Compact disc player
Tungsten carbide	Kodak disc camera
Litton Pocket socket wrench	Supercharger
Bell Tourlite bicycle helmet	Radial tires
Turbocharge	Nonwoven fabrics
Magnetohydrodynamics	VelCro
Integrated circuits	Chemical milling
Electrical discharge machining	Stretch forming
Electrochemical machining	Prestressed concrete
Explosive forming	Particle board
high strength concrete	Transponders
Plywood	Thermionic power
Tower crane	Fuel injection
Light emitting diodes	Supercritical wing
Linear induction motors	Video tape cassettes
Electronic ignition	Polaroid camera
Vinyl chloride	Achromatic lens
Inertial guidance	Aqualung
Surface effect vehicles	Bathyscaphe
Altimeter—radar	Derailleur gear

Barbed wire manufacture	Float glass
Contact lens	Magnetic tape recording
Dynamometer	Optical readers
Basic oxygen process for steel making	Shell moulding
Video tape cassette	Laser
Automatic pilot	Escalator
Thermite welding	Flight recorder
Fibre optics	Flight simulation
Fresnel lens	Fuel cell
Heart pacemaker	Heat pump
Holography	Hydrofoil
Microphone	Thermionic power
Crease-resisting fabrics	Fluorescent lighting
Telephone	Telegraph
Cable television	Gyrocompass
Turbine engine	Refrigeration
Superheterodyne radio circuit	Parachute
Potentiometer	Power brakes
Power steering	Pressure cooker
Quartz clock	Stirling engine
Tachometer	Wankel engine
Xerography	Electostatic machine
Citizens band radio	Automatic transmission
Bakelite	Ballpoint pen
Power metallurgy	Continuous casting of steel
Tufting	Transistor
Numerical control	Fuel cells

SUMMARY

Creativity in technologies is directly affected by the personal traits and abilities of the researcher/inventor and the social and environment in which the creative activity takes place.

Various individuals have identified the following personal traits as typical of successful researchers:

( ) Challenged intellectually by problem situations
( ) Self motivated
( ) Non-conforming to organizational rules
( ) Willing to take risks
( ) See things differently or unconventionally
( ) Focus on identifying the "true" problem
( ) Little regard for social and textbook rules
( ) Recognize and respond to societal needs
( ) Disassociate themselves from the problem and let their subconscious operate
( ) Engage in disorganized thinking
( ) Use existing knowledge systematically
( ) Resist adverse premature opinions of others
( ) Intense and focused when working on the problem
( ) Are persistent and stay with a problem once the problem is identified

These traits are best fostered by companies interested in innovation. Companies that have been most successful recognize the need to:

1. Foster champions of product ideas.
2. Emphasize long-term growth over short-term profits.
3. Focus on individuals and their unique abilities.
4. Emphasize the research mission based on the goals of the company.
5. Emphasize technological leadership as opposed to market domination.
6. Willingly accept uncertainty in product and process research and development projects.

When a majority of these personal company traits are present, the likelihood of a continuing flow of new products and improved processes is enhanced.

REFERENCES

Alexander, Tom. "The Right Remedy for R & D lag." *Fortune,* January 25, 1982.

Associated Press. "Prolific Inventor Continues His Creative Work at Age 86." *Dominion Post,* Wednesday, August 28, 1985.

"Basement Tinkerer Scoops the Pros." *Business Week,* March 16, 1968.

Bonasso, Samuel G. The Tension Arch Concept. Paper Number 1BC-84-13 delivered to International Bridge Conference, Pittsburgh, Pennsylvania, June 1984.

Brumley, Cal. "Affluent Inventor." *The Wall Street Journal,* Friday, August 31, 1962, p. 1.

Compton, Dale W. (ed.). The Interaction of Science and Technology. Urbana: University of Illinois Press, 1969.

Editors. "R & D Magazine Selects 100 Most Significant Technological Advances." *Research and Development,* October 1985.

Fagenbaum, Joel. "Patrick E. Haggerty: Engineer and Visionary." *IEEE Spectrum,* December 1980.

Freeman, C. *The Economics of Industrial Innovation.* London: Penguin Books, 1974.

Gardner, Q. David. "The Independent Inventor." *Datamation,* September 21, 1982, pp. 12-22.

Haggerty, Patrick E. Three Lectures at the Salzburg Seminar on Multinational Enterprise. Dallas, Texas, 1977.

Harris, S. T. "Marketing the Product." Twenty-fifth Anniversary Observance-Transistor Radio and Silicon Transistor. Dallas, Texas: Texas Instruments, Inc., 1980.

Himmelman, Laurie (ed.). "Recipe for Invention: A Pound of Perspiration + a Dash of Inspiration = Flash." *Varian Associate Magazine,* Vol. 24, No. 7, August 1979.

Jewkes, John; Sawers, David and Stillerman, Richard. *The Sources of Invention,* New York: St. Martin's Press, 1979.

Kay, Neil M. *The Innovating Firm: A Behavioral Theory of Corporate R & D.* New York: St. Martin's Press, 1979.

Kline, Stephen J. "An Appropriate Model for Industrial Innovation." *Science, Technology and Society,* No. 49, September 1985.

Kroll, W. J. "how Commercial Titanium and Zirconium Were Born." *Journal of the Franklin Institute,* September 1955.

Land, Edwin H. Photographic Product Comprising a Rupturable Container Carrying a Photographic Processing liquid. U.S. Patent No. 2,543,181. February 27, 1951.

Langrish, L. et al. *Wealth From Knowledge.* New York: John Wiley and Sons, 1972.

Maiman, Theodore H. Ruby Laser System. U.S. Patent No. 3,353,115. November 29, 1965.

Nadler, Elsa (ed.). "Something from a 'Do-Nothing.'" *Inquiry,* Morgantown, WV: West Virginia University Office of Sponsored Programs, Spring 1985.

Pearson, John W. "Organizing the R & D-Manufacturing-Marketing Interface." *Chamtech,* 1983, pp. 470–475.

Peters, Thomas. "The mythology of Innovation, or a Skunkworks Tale, Part I." *The Standford Magazine,* Summer 1983.

Peters, Thomas. "The Mythology of Innovation, or a Skunkworks Tale, Part II." *The Standford Magazine,* Fall 1983.

Reid, T. R. "The Chip." *Science 85,* February 1985, pp. 32–41.

Reid, T. R. "The Texas Edison." *Texas Monthly,* July 1982.

Ross, Ian M. "Successful R & D Management: Catalyst for Competitive Advantage." *Vital Speeches of the Day,* April 1, 1986, pp. 374–378.

Ruben, Samuel. Inventions in Chemistry. *Proceedings of a Symposium, American Society of Engineering Education.* University of Tennessee, Knoxville. June 17, 1976, pp. 29–41.

Ruben, Samuel. Inventions in Society-Response to Industrial Needs. 1981 Armstrong Memorial Lecture. Department of Electrical Engineering, Columbia University. April 17, 1981.

Sahal, Devendra. Patterns of *Technological Innovation Reading: Addison-Wesley* Publishing Company, Inc. 1981.

Schmitt, Patrick E. Three Lectures at the Salzburg Seminar on Multinational Enterprise. Dallas, Texas. 1977.

Stewart, P. J. Correspondence with P. W. DeVore. 1985.

"Something is Out of Whack in U. S. Business Management." *U.S. News and World Report,* July 15, 1985, pp. 53-56. Stiller, Alfred H. and Smith, James E. Oscillatory Motion Apparatus. Europeans Patent No. 0167149. February 7, 1985.

Tornatzky, Louis G. et al. *The Process of Technological Innovation: Reviewing the Literature.* Washington, D.C.: National Science Foundation, 1983.

U. S. Department of Commerce. *U. S. Industrial Outlook,* 1986. Washington, D.C.: U.S. Government Printing office, 1986.

U. S. Department of Transportation. *Innovation in Public Transportation.* U. S. Government Printing Office, 1976.

Vincenti, Walter G. "Technological Knowledge Without Science: The Innovation of Flush Riveting in American Airplanes, ca. 1930–ca. 1950." *Technology and Culture,* Vol. 25, No. 3. July 1984.

Walton, R. R. Personal Correspondence and Discussion with P. W. DeVore, 1985.

Westney, D. Eleanor and Sakakibara, Kiyonori. "Designing the Designers: Computer R & D in the United States and Japan." *Technology Review,* April 1986, pp. 24-31.

Abilities for a Technological World

Section IV

STANDARD 4—ABILITIES FOR A TECHNOLOGICAL WORLD
Technology teacher education program candidates develop abilities for a technological world within the contexts of *the Designed World.*
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 4. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Select design problems and include appropriate criteria and constraints for each problem. • Evaluate a design, assessing the success of a design solution, and develop proposals for design improvements. • Analyze a designed product, and identify the key components of how it works and how it was made. • Operate and maintain technological products and systems.
Performance Indicators:
• Develop and model a design solution. • Complete an assessment to evaluate merits of design solution. • Operate a technological device and/or system. • Diagnose a malfunctioning system, restore the system, and maintain the system. • Investigate the impacts of products and systems on individuals, the environment, and society.
Disposition Indicators:
• Assess the impacts of products and systems. • Follow safe practices and procedures in the use of tools and equipment. • Judge the relative strengths and weaknesses of a designed product from a consumer perspective. • Exhibit respect by properly applying tools and equipment to the processes for which they were designed. • Design and use instructional activities that emphasized solving real world open-ended problems.

Standards for Technological Literacy: Content for the Study of Technology

Chapter 7

William E. Dugger, Jr.
International Technology Education Association
Technology for All Americans
51st CTTE Yearbook, 2002

What is the importance of standards on public education in the United States? In an article in *Education Week* (October 21, 1998), Christopher T. Cross, president of the Council for Basic Education, stated, "I am often asked in forums across the country whether standards are here to stay or simply a passing fad that will soon be replaced by another fad. My answer remains firm and consistent: Standards are here to stay. The effort has survived almost a decade of attempts to sabotage it and, in fact, public support is stronger than ever." He also stated that most policymakers in education have yet to understand that content standards are only the first step in the process which involves curriculum revision, assessment standards, program standards, teacher in-service standards, and teacher pre-service standards. There must be close collaboration between all of these components to assure that the standards will act as a positive catalyst for reform across the educational spectrum. The bottom line is whether student learning is improving.

The International Technology Education Association (ITEA) released *Standards for Technological Literacy: Content for the Study of Technology* (*Standards for Technological Literacy*) on April 6, 2000, at its conference in Salt Lake City. This publication was the culminating effort of over 4,000 educators, administrators, engineers, scientists, parents, and others over a four-year time period (1996-2000). These standards, in the later versions, went through a rigorous review by the technology community, the National Research Council (NRC), and the National Academy of Engineering (NAE). It is significant to note that this marks the first time that the NAE supported a publication that it did not write.

Broadly speaking, standards are written statements about what is valued in education that can be used for making a judgment of quality. More specifically, content standards specify what students should know and be able to do in technology. They indicate the knowledge and processes that are essential in the study of technology that should be taught and learned in school in grades K-12. *Standards for Technological Literacy* is not a curriculum. A curriculum specifies how the content is delivered day-in and day-out by the teacher(s) which includes the structure, organization, balance, sequencing, and presentation of the content in the laboratory-classroom from the learner's point of view. Curriculum developers, teachers, and others should use *Standards for Technological Literacy* as a guide for developing curriculum. The standards do not specify what should go on in the laboratory-classroom. Similarly, *Standards for Technological Literacy* does not prescribe courses or programs (groups of courses) at grade levels. Qualified education personnel at the local or state level should develop the curriculum, courses, and programs. *Standards for Technological Literacy* is voluntary and does not represent a federal policy or mandate. Finally, *Standards for Technological Literacy* does not prescribe an assessment process that deals with how well students learn the content in technology.

Standards for Technological Literacy provides a vision for what a technologically literate person should be. If a student goes through an articulated standards-based technology education program from grades K-12, he or she will be technologically literate at graduation from high school. *Standards for Technological Literacy* was created with the following guiding principles:

- They offer a common set of expectations for what students should learn in the study of technology.
- They are developmentally appropriate for students.
- They provide a basis for developing meaningful, relevant, and articulated curricula at the local, state, and provincial levels.
- They promote content connections with other fields of study in grades K-12.
- They encourage active and experiential learning.

What is included in *Standards for Technological Literacy*? How is it formatted and organized? What are the benchmarks that follow each Standard? What information in the publication prepares a person philosophically for technological literacy as interpreted through the standards? Are there examples of classroom activities provided that will help in interpreting the standards into everyday teaching and learning? The answers to these and other questions are found next in this chapter.

A BRIEF TOUR OF STANDARDS FOR TECHNOLOGICAL LITERACY

Standards for Technological Literacy is designed to help a person easily find information that is needed. It is laid out to be user-friendly, and the table of contents at the front of the book coupled with the index at the end of the book help the reader to locate what is available. There is plenty of "white space" on the pages to allow for notes to be written by the user.

Standards for Technological Literacy begins with an impressive foreword (2000, p. v) by William A. Wulf, President of the NAE. He documents a need for technological literacy in this country. Moreover, Wulf calls for support for *Standards for Technological Literacy* as a dynamic document, which can enhance the technological literacy of the nation.

Standards for Technological Literacy includes the following parts:

- Chapter 1 (Preparing Students for a Technological World) establishes the need for technological literacy for everyone through a standards-based study of technology.
- Chapter 2 (Overview of *Standards for Technological Literacy*) describes the format of the standards and their enabling benchmarks. Also presented in this chapter is a discussion of the primary users of the standards.

The following five chapters discuss the standards and benchmarks in five major categories:

- Chapter 3 (The Nature of Technology) presents what students should understand about the nature of technology in order to become technologically literate. It includes standards, which address what technology is, the common core of concepts, which permeate all technologies, and the relationships among various technologies and among technology and other fields of study.
- Chapter 4 (Technology and Society) deals with how technology affects society and the environment, as well as how society influences the development of technology, and how technology has changed and evolved over the course of human history.

- Chapter 5 (Design) discusses what the attributes of design are, and specifically how students will develop an understanding of engineering design. Also in this chapter is a standard that presents what students should know about some other problem solving approaches, such as troubleshooting, research and development, invention and innovation, and experimentation.
- Chapter 6 (Abilities for a Technological World) presents the development of important abilities by students for a technological world, which include applying the design process, using and maintaining technological products and systems, and assessing products and systems.
- Chapter 7 (The Designed World) is the product of a design process, which provides ways to turn resources—materials, tools and machines, people, information, energy, capital, and time—into products and systems. It includes standards in major organizational areas of technology, including medical technologies, agricultural and bio-related technologies, energy and power technologies, information and communication technologies, transportation technologies, manufacturing technologies, and construction technologies.
- Chapter 8 (Call to Action) presents the challenges which need to be overcome in achieving the vision of *Standards for Technological Literacy* by various individuals and groups including teachers, curriculum developers, publishers, equipment designers and manufacturers, students, the overall educational community, parents, the engineering profession, researchers, and other technology professionals.
- Appendices include a brief history of the ITEA's Technology for All Americans Project, a listing of all the 20 standards, a compendium of all the benchmark topics under the standards, and an articulated curriculum vignette for grades K-12. Additionally, in the appendix is a list of references, an acknowledgements section recognizing the contributions of many individuals and groups who assisted in the development and review of *Standards for Technological Literacy*, a glossary of most used terms in the book, and an index.

STRUCTURE OF STANDARDS FOR TECHNOLOGICAL LITERACY

Standards

The standards specify what every student should know and be able to do in order to be technological literate. They offer criteria to judge progress toward a vision of technological literacy for all students. All standards should be met for a student to obtain the optimal level of standards technological literacy at graduation from high school. There are 20 standards in the book, which are expressed in sentence form. *Standards for Technological Literacy* should be applied in conjunction with other national, state, and locally developed standards in technological studies and for other fields of study. The standards should be integrated with one another rather than being presented as separate parts (e.g., *Standard* 1 with *Standard* 8 or *Standard* 19 with 17 and 20).

The individual standards fall into two types: what students should know and understand about technology, and what they should be able to do. The first type, which could be termed "cognitive" standards, sets out basic knowledge about technology—how it works, and its place in the world – that students should have in order to be technologically literate. The second type, the "process" standards, describes the abilities that students should have. The two types of standards are complementary. For example, a student can be taught in a lecture about a design process, but the ability to actually use a design process and to apply it for finding a solution to a technological problem comes only with hands-on experience. Likewise, it is difficult to perform a design process effectively without having some theoretical knowledge of how it is usually done. See Table 4-1 for a comprehensive listing of the standards under each of the categories in Chapters 3-7.

After each standard, a brief (one to two page) narrative follows which explains the intent of the standard. Grade level material is presented next for grades K-2, 3-5, 6-8, and 9-12. Under each grade level, a narrative follows that further explains the standard specifically at the grade level under discussion and provides suggestions on how the standard can be implemented in the laboratory-classroom by the teacher.

Table 7-1. The Standards for Technological Literacy

The Nature of Technology

Standard 1. Students will develop an understanding of the characteristics and scope of technology.

Standard 2. Students will develop an understanding of the core concepts of technology.

Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 5. Students will develop an understanding of the effects of technology on the environment.

Standard 6. Students will develop an understanding of the role of society in the development and use of technology.

Standard 7. Students will develop an understanding of the influence of technology on history.

Design

Standard 8. Students will develop an understanding of the attributes of design.

Standard 9 Students will develop an understanding of engineering design.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

Standard 11. Students will develop the abilities to apply the design process.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

The Designed World

Standard 14. Students will develop an understanding of and be able to select and use medical technologies.

Standard 15. Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.

Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 18. Students will develop an understanding of and be able to select and use transportation technologies.

Standard 19. Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20. Students will develop an understanding of and be able to select and use construction technologies.

References that were used in the development of *Standards for Technological Literacy* include the following standards in other subject areas: *National Science Education Standards* (National Research Council, 1996), *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993), *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989), *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics, 2000), and others. It is important to keep in mind that the standards are the target and these should be kept as ultimate goals for achieving technological literacy by all students.

Benchmarks

Each grade level discussion is followed by a series of benchmarks, which provide the fundamental content elements under the broadly stated standards (See Table 7-2). Benchmarks, which are statements that provide the specific knowledge and abilities that enable students to meet a given standard, are provided for each of the 20 standards at the K-2, 3-5, 6-8, and 9-12 grade levels. The benchmarks are identified by an alphabetical listing (e.g., A, B, C) and are highlighted in bold type. They are followed by supporting sentences (not in bold) that provide further detail, clarity, and

Table 7-2. A Representative Standard and Benchmarks

Standard 8—Students will develop an understanding of the attributes of design.

In order to realize the attributes of design, students in grades 3–5 should learn that

C. The design process is a purposeful method of planning practical solutions to problems. The design process helps convert ideas into products and systems. The process is intuitive and includes such things as creating ideas, putting the ideas on paper, using words and sketches, building models of the design, testing out the design, and evaluating the solution.

D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design. Technological designs typically have to meet requirements to be successful. These requirements usually relate to the purpose or function of the product or system. Other requirements, such as size and cost, describe the limits of a design.

Figure 7-1. Structure of the Standards

	Standards	Benchmark K-2	3-5	6-8	9-12
The Nature of Technology	*The characteristics and scope of technology				
	*The core concepts of technology				
	*The relationships among technologies and the connections between technology and other fields of study				
Technology and Society	*The cultural, social, economic, and political efffects of technology				
	*The effects of technology on the environment				
	*The role of society in the development and use of technology				
	*The influence of technology on history				
Design	*The attributes of design				
	*Engineering design				
	*The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving				
Abilities for a Technological World	*Apply the design process				
	*Use and maintain technological products and systems				
	*Assess the impact of products and systems				
The Designed World	*Medical technologies				
	*Agricultural and related biotechnologies				
	*Energy and power technologies				
	*Information and communication technologies				
	*Transportation technologies				
	*Manufacturing technologies				
	*Construction technologies				

examples. An example of a standard and its enabling benchmarks (C and D) for grades 3-5 is shown in Table 7-2.

The standards and benchmarks were established for guiding a student's progress toward technological literacy. To better understand the conceptual organizational structure between the standards, the categories, and benchmarks, please refer to Figure 7-1. The benchmarks, which are not listed in Figure 7-3 for each grade level for each standard, are required in order for students to meet the standards. Teachers may create additional benchmarks if they think that these will help students to meet a specific standard.

The benchmarks are articulated from grades K-2 through 9-12 to progress from very basic ideas at the early elementary school level to more complex and comprehensive ideas at the high school level. Certain content "concepts" are found in the benchmarks, which extend across various levels to ensure continual learning of an important topic related to a standard.

Vignettes

A selection of vignettes is included in *Standards for Technological Literacy* to provide snapshots of laboratory-classroom experiences. They offer detailed examples of how the standards can be implemented by a teacher. A large majority of the vignettes were authentic in that they have been successfully used in an actual laboratory-classroom with students. A few of the vignettes were generated especially for these standards and are fictional—they were not tried and tested. Readers should be cautioned that any vignette is presented as a possible example and should not be interpreted as a curriculum.

A COMPENDIUM OF STANDARDS AND BENCHMARKS FOR STANDARDS FOR TECHNOLOGICAL LITERACY

A compendium is provided in *Standards for Technological Literacy*, which provides a summary of the content included in the 20 standards and their enabling benchmarks by grade levels of K-2, 3-5, 6-8, and 9-12. While the compendium provides an abbreviated overview of the standards and benchmarks, it is recommended that the reader use the full text in the actual standards and benchmarks to comprehend the accurate meaning intended by the developers of this document. A compendium of technology standards is presented in Table 7-3.

Table 7-3. Compendium of Major Topics for *Technology Content Standards*

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Nature of Technology **Standard 1:** The Characteristics and Scope of Technology	• Natural world and human-made world • People and technology	• Things found in nature and in the human-made world • Tools, materials, and skills • Creative thinking	• Usefulness of technology • Development of technology • Human creativity and motivation • Product demand	• Nature of technology • Rate of technological diffusion • Goal-directed research • Commercialization of technology
Standard 2: The Core Concepts of Technology	• Systems • Resources • Processes	• Systems • Resources • Requirements • Processes	• Systems • Resources • Requirements • Trade-offs • Processes • Controls	• Systems • Resources • Requirements • Optimization and Trade-offs • Processes • Controls
Standard 3: The Relationships Among Technologies and the Connections Between Technology and Other Fields	• Connections between technology and other subjects	• Technologies integrated • Relationships between technology and other fields of study	• Interaction of systems • Interrelation of technological environments • Knowledge from other fields of study and technology	• Technology transfer • Innovation and Invention • Knowledge protection and patents • Technological knowledge and advances of science and mathematics and vice versa
Technology and Society **Standard 4:** The Cultural, Social, Economic, and Political Effects of Technology	• Helpful or harmful	• Good and bad effects • Unintended consequences	• Attitudes toward development and use • Impacts and consequences • Ethical issues • Influences on economy, politics, and culture	• Rapid or gradual changes • Trade-offs and effects • Ethical implications • Cultural, social, economic, and political changes

Table 7-3. Compendium of Major Topics for *Technology Content Standards* (continued)

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Standard 5: The Effects of Technology on the Environment	• Reuse and/or recycling of materials	• Recycling and disposal of waste • Affects environment in good and bad ways	• Management of waste • Technologies repair damage • Environmental vs. economic concerns	• Conservation • Reduce resource use • Monitor environment • Alignment of natural and technological processes • Reduce negative consequences of technology • Decisions and trade-offs
Standard 6: The Role of Society in the Development and Use of Technology	• Needs and wants of individuals	• Changing needs and wants • Expansion or limitation of development	• Development driven by demands, values, and interests • Inventions and innovations • Social and cultural priorities • Acceptance and use of products and systems	• Different cultures and technologies • Development decisions • Factors affecting designs and demands of technologies
Standard 7: The Influence of Technology on History	• Ways people have lived and worked	• Tools for food, clothing, and protection	• Processes of inventions and innovations • Specialization of labor • Evolution of techniques, measurement, and resources • Technological and scientific knowledge	• Evolutionary development of technology • Dramatic changes in society • History of technology • Early technological history • The Iron Age • The Middle Ages • The Renaissance • The Industrial Revolution • The Information Age

Table 7-3. Compendium of Major Topics for *Technology Content Standards* (continued)

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Design **Standard 8:** The Attributes of Design	• Everyone can design • Design is a creative process	• Definitions of design • Requirements of design	• Design leads to useful products and systems • There is no perfect design • Requirements	• The design process • Design problems are usually not clear • Designs need to be refined • Requirements
Standard 9: Engineering Design	• Engineering design process • Expressing design ideas to others	• Engineering design process • Creativity and considering all ideas • Models	• Iteration • Brainstorming • Modeling, testing, evaluating, and modifying	• Design principles • Influence of personal characteristics • Prototypes • Factors in engineering design
Standard 10: The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving	• Asking questions and making observations • All products need to be maintained	• Troubleshooting • Invention and innovation • Experimentation	• Troubleshooting • Invention and innovation • Experimentation	• Research and development • Researching technological problems • Not all problems are technological or can be solved • Multidisciplinary approach
Abilities for a Technological World **Standard 11:** Apply the Design Process	• Solve problems through design • Build something • Investigate how things are made	• Collecting information • Visualize a solution • Test and evaluate solutions • Improve a design	• Apply design process • Identify criteria and constraints • Model a solution to a problem • Test and evaluate • Make a product or system	• Identify a design problem • Identify criteria and constraints • Refine the design • Evaluate the design • Develop a product or system using quality control • Reevaluate final solution(s)

Table 7-3. Compendium of Major Topics for *Technology Content Standards* (continued)

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Standard 12: Use and Maintain Technological Products and Systems	• Discover how things work • Use tools correctly and safely • Recognize and use everyday symbols	• Follow step-by-step instructions • Select and safely use tools • Use computers to access and organize information • Use common symbols	• Use information to see how things work • Safely use tools to diagnose, adjust, and repair • Use computers and calculators • Operate systems	• Document and communicate processes and procedures • Diagnose a malfunctioning system • Troubleshoot and maintain systems • Operate and maintain systems • Use computers to communicate
Standard 13: Assess the Impact of Products and Systems	• Collect information about everyday products • Determine the qualities of a product	• Use information to identify patterns • Assess the influence of technology • Examine trade-offs	• Design and use instruments to collect data • Use collected data to find trends • Identify trends • Interpret and evaluate accuracy of information	• Collect information and judge its quality • Synthesize data to draw conclusions • Employ assessment techniques • Design forecasting techniques
The Designed World **Standard 14:** Medical Technologies	• Vaccinations • Medicine • Products to take care of people and their belongings	• Vaccines and medicine • Development of devices to repair or replace certain parts of the body • Use of products and systems to inform	• Advances and innovations in medical technologies • Sanitation processes • Immunology • Awareness about genetic engineering	• Medical technologies for prevention and rehabilitation • Telemedicine • Genetic therapeutics • Biochemistry

Table 7-3. Compendium of Major Topics for *Technology Content Standards* (continued)

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Standard 15: Agricultural and Related Biotechnologies	• Technologies in agriculture • Tools and materials for use in ecosystems	• Artificial ecosystems • Agriculture wastes • Processes in agriculture	• Technological advances in agriculture • Specialized equipment and practices • Biotechnology and agriculture • Artificial ecosystems and management • Development of refrigeration, freezing, dehydration, preservation, and irradiation	• Agricultural products and systems • Biotechnology • Conservation • Engineering design and management of ecosystems
Standard 16: Energy and Power Technologies	• Energy comes in many forms • Energy should not be wasted	• Energy comes in different forms • Tools, machines, products, and systems use energy to do work	• Energy is the capacity to do work • Energy can be used to do work using many processes • Power is the rate at which energy is converted from one form to another • Power systems • Efficiency and conservation	• Law of Conservation of Energy • Energy sources • Second Law of Thermodynamics • Renewable and non renewable forms of energy • Power systems are a source, a process, and a load

Table 7-3. Compendium of Major Topics for *Technology Content Standards* (continued)

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Standard 17: Information and Communication Technologies	• Information • Communication • Symbols	• Processing information • Many sources of information • Communication • Symbols	• Information and communication systems • Communication systems encode, transmit, and receive information • Factors influencing the design of a message • Language of technology	• Parts of information and communication systems • Information and communication systems • The purpose of information and communication technology • Communication systems and sub-systems • Many ways of communicating • Communication through symbols
Standard 18: Transportation Technologies	• Transportation system • Individuals and goods • Care of transportation products and systems	• Transportation system use • Transportation systems and subsystems	• Design and operation of transportation systems • Subsystems of transportation system • Governmental regulations • Transportation processes	• Relationship of transportation and other technologies • Intermodalism • Transportation services and methods • Positive and negative impacts of transportation systems • Transportation processes and efficiency

Table 7-3. Compendium of Major Topics for *Technology Content Standards* (continued)

Standard	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
Standard 19: Manufacturing Technologies	• Manufacturing systems • Design of products	• Natural materials • Manufacturing processes • Consumption of goods • Chemical technologies	• Manufacturing systems • Manufacturing goods • Manufacturing processes • Chemical technologies • Materials use • Marketing products	• Servicing and obsolescence • Materials • Durable or non-durable goods • Manufacturing systems • Interchangeability of parts • Chemical technologies • Marketing products
Standard 20: Construction Technologies	• Different types of buildings • How parts of buildings fit	• Modern communities • Structures • Systems used	• Construction designs • Foundations • Purpose of structures • Buildings systems and sub-systems	• Infrastructure • Construction processes and procedures • Requirements • Maintenance, alterations, and renovation • Prefabricated materials

WHAT IMPACTS WILL THE STANDARDS HAVE ON TECHNOLOGY TEACHER EDUCATION PROGRAMS?

College and University Teacher Education Programs

Standards for Technological Literacy will have a major impact on college and university technology teacher education programs throughout the country. The colleges and universities preparing the teachers for the future will need to put the standards into practice. Since the study of technology is a vital field of education, those in charge of teacher education programs need to revise their curricula and teaching methodologies to reflect the vision of *Standards for Technological Literacy*. Faculty members in technology teacher education programs should address *Standards for Technological Literacy* and what they mean for enhancing the technological literacy of future students. Becoming an effective technology teacher is an on-going process that begins in the earliest days of pre-service preparation in the undergraduate years and continues throughout one's professional career. Since the study of technology is a continuously changing field of study, teachers must be well prepared and have the ability and desire to stay informed and current on technological and educational advances throughout their careers.

The preparation of teachers should assume that all pre-service students are prepared in the content areas as specified in *Standards for Technological Literacy*. It is imperative that the 20 standards be infused into the technology courses, the technological laboratory courses, professional courses, the clinical experiences, and the university core courses, which are taken by each pre-service student.

The preparation of teachers requires that the knowledge and processes of technology be integrated within pedagogical courses. This will provide a connection between the study of technology and technology education. Teachers need to be lifelong learners themselves to inspire in others the desire to continue learning as an integral part of life. Colleges and universities can provide excellent examples here through their professors. Professors can set examples by being scholars, researchers, and professionals keenly interested in and involved in the study of technology.

As previously stated, those who prepare technology teachers should review and revise undergraduate and graduate degree programs by using

Standards for Technological Literacy as the basis for teaching technology. Furthermore, strategies can be designed and implemented for recruiting and preparing a sufficient number of newly trained and credentialed technology education teachers.

Alternative Teacher Education Programs and Certification/Licensure

Alternate certification/licensure programs may be established in states and provinces with serious shortages of technology teachers. If alternate certification/licensure programs are established, they should comply with *Standards for Technological Literacy*. The institutions and agencies providing alternate certification/licensure should become very familiar with the content listed in *Standards for Technological Literacy* so that the students enrolled in the alternate certification/licensure program will become knowledgeable about and know how to use *Standards for Technological Literacy*. The teacher being prepared under alternate certification/licensure programs should be qualified both philosophically as well as in the content dealing with the teaching of technology.

Other Leadership Roles for Technology Teacher Education Faculty

It is also necessary to develop in-service programs to teach technology educators how to implement *Standards for Technological Literacy*. Supervisors are encouraged to provide support and philosophical leadership for reform in the field because they are in an ideal position to implement long-range plans for improving the delivery of technology education subject matter at the local, district, state, and province levels. It is vital to gain the support of the technology education profession in the acceptance and implementation of *Standards for Technological Literacy*. By using this document as a basis for modifying their instruction, teachers will demonstrate the importance of technological studies, the value of technological literacy, and their own abilities to teach about technology.

Other leadership roles for technology teacher education faculty include serving as ITEA/CTTE/NCATE program reviewers. This is a very important role that the faculty member can play in assessing other teacher education programs in the United States. Also, faculty members can work on committees when their undergraduate degree program comes up for NCATE approval. This will give them valuable experience in planning to assure that they are in compliance with the *ITEA/CTTE/NCATE*

Curriculum Guidelines (ITEA/CTTE/NCATE, 1997). Additionally, technology teacher education faculty can work with committees within their program to assure that they meet certification/licensure requirements which are based on *Standards for Technological Literacy*.

Teacher education programs can provide valuable in-service to technology teachers. This can be done through regular graduate courses or conducting special workshops for teachers within the state or at certain school districts or regions. Historically, teacher education programs in the United States have provided valuable in-service to technology teachers who are becoming re-certified or being certified under temporary license or requirements.

Another leadership role for technology teacher education faculty is to provide service to other agencies in education. These include working with state departments of education and state supervisors of technology education in enhancing the teaching of technology within a given state. Also, it is very important that faculty in technology teacher program work with faculty from other university disciplines to develop interdisciplinary technology-based courses that contribute to the education of future technology education teachers.

PHASE III OF THE TECHNOLOGY FOR ALL AMERICANS PROJECT

The ITEA's Technology for All Americans Project is currently developing additional standards to complement and support *Standards for Technological Literacy*. This is made possible because of continued support and funding from the NSF and the NASA. These additional standards include:

- Assessment Standards for Technological Literacy
- Professional Development Standards for Technological Literacy
- Program Standards for Technological Literacy

All of these standards will impact teacher education programs. Additionally, the Council on Technology Teacher Education (CTTE) is using *Standards for Technological Literacy* to revise the *ITEA/CTTE NCATE Curriculum Guidelines* (ITEA/CTTE/NCATE, 1997), accreditation guidelines for technology education.

SUMMARY

For the first time in history, the technology education profession has a set of nationally developed and reviewed standards that prescribes what the content for the study of technology should be. The ultimate vision of these standards is that every student should and can become technologically literate. The difficult task is what lies ahead in implementing *Standards for Technological Literacy* in classrooms in school districts across the nation, in state departments of education, and in teacher preparation programs at colleges and universities. The seeds of progress have been sown, now the profession will have to nurture and cultivate them to create a new level of technology understanding and literacy for the generations to come

REFERENCES

American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

Cross, C. (October 21, 1998). The standards wars: Some lessons learned. *Education Week*, 32-35.

International Technology Education Association (ITEA). (1996). *A rationale and structure for the study of technology.* Reston, VA: Author.

International Technology Education Association (ITEA). (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

International Technology Education Association/Council on Technology Teacher Education/National Council for Accreditation of Teacher Education (ITEA/CTTE/NCATE). (1997). *ITEA/CTTE/NCATE Curriculum guidelines.* Reston, VA: International Technology Education Association.

National Council of Teacher of Mathematics (NCTM). (1989). *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Research Council (NRC). (1996). *National science education standards.* Washington, D.C.: National Academy Press.

The Designed World

Section V

STANDARD 5—THE DESIGNED WORLD
Technology teacher education program candidates develop an understanding of the nature of technology within the context of the *Designed World*.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 5. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Analyze the principles of various medical technologies as part of the designed world. • Analyze the principles of various agricultural and related biotechnologies as part of the designed world. • Analyze the principles, concepts and applications of energy and power technologies as part of the designed world. • Analyze the principles, concepts and applications of information and communication technologies as part of the designed world. • Analyze the principles of various transportation technologies that are part of the designed world. • Analyze the principles, concepts, and applications of manufacturing technologies as part of the designed world. • Analyze the principles, concepts, and applications of construction technologies as part of the designed world.
Performance Indicators:
• Select and use appropriate technologies in a variety of contexts including medical, agricultural and related biotechnologies, energy and power applications, information and communications, transportation, manufacturing, and construction.
Disposition Indicators:
• Effectively use and improve technology in a variety of contexts including medical, agricultural and related biotechnologies, energy and power applications, information and communications, transportation, manufacturing, and construction.

Education About Technology

Chapter 8

Michael R. Kozak and Janet Robb[1]

40th CTTE Yearbook, 1991

> If we compress all of the 15 billion years of the evolution of the universe as we know it into a single 24-hour day, the Big Bang is over in less than a ten billionth of a second. Stable atoms form in about four seconds; but not for several hours, until early dawn, do stars and galaxies form. Our own solar system must wait for early evening, around 6 p.m. Life on earth begins around 8 p.m.; the first vertebrates crawl onto land at about 10:30 at night. Dinosaurs roam from 11:35 p.m. until four minutes to midnight. Our ancestors first walk upright with ten seconds to go. The Industrial Revolution and all our modern age occupy less than the last thousandth of a second. Yet, in this fraction of time, the face of this planet has been changed almost as much as in all the aeons before (Myers, 1984, p.14).

Exactly how are people changing this planet? In one day, Americans: (a) use 450 billion gallons of water, (b) produce 500,000 car and truck tires while spending $250,000 to get rid of the old ones, (c) lay about 3,000 acres of pavement, (d) produce over 60 million newspapers on 23,000 tons of paper, (e) use 57 billion kilowatt hours of energy, and (f) add 150,000 miles to the telephone network (Parker, 1985).

The escalating impact of technology may also be demonstrated by considering the effect of a single technological event. For example, consider how one of the Hiroshima survivors would describe the impact of that **single** event in the history of technology.

NOTE: [1]Michael R. Kozak is Associate Professor in the Department of Industrial Technology at the University of North Texas, Denton, Texas. Janet Robb is USAID Design and Technology Consultant in Botswana, Africa for Florida State University.

THE CHALLENGE OF TECHNOLOGY

Technology is simultaneously the: (a) major component of industrial and economic activity, (b) significant determinant of military capacity, (c) a frequent focus of recreational activities, (d) coveted cornerstone of a desirable future, and (e) fervent hope for the resolution of our pressing problems. Systematic analysis reveals technology as the process of creating, utilizing, and discarding of adaptive means—including tools, materials, processes, energy, and information—and relating these individual elements and/or collective systems to individuals, society, and technology feeds on all appropriate knowledge and imagination to provide the know-how of what is possible (DeVore, 1980; Dyrenfurth, 1984).

Rate of Change

American industrial productivity seems to be continuing its steady 15-year decline as one industry after another yields to international competition. Each year in the United States, approximately 10,000 industrial companies close their doors for good. Alienation and isolation in the work place and/or community have often been a result of technological growth or change (Davis, 1980).

Knowledge and skills that have provided employment for a generation or longer are being made useless by exponential technological growth and are being replaced with new jobs that require new knowledge and new skills.

In the computer industry, for example, William C. Norris (Naisbitt, 1982), then the Chief Executive Officer of control Data Corporation, projected a job growth during the 80s of 147 percent for computer maintenance technicians and 107 percent growth for computer systems analysts in his industry alone. Innovations will continue to make obsolete that which is commonplace in today's industrial environment.

Meta-technology can better explain the massive underemployment factor. Meta-technology is the concept that, as one innovation or improvement occurs, it generates a ripple effect with implications for other aspects of industry, which in turn, affects still more areas of technological productivity. Massive unemployment accompanies these innovations, usually because, in reality, industry exists to make a profit, not to provide employment.

Technology has existed since the first human began to seek control over the environment. The manipulation of stone, bone, hide, and metal led to an ever increasing range of applications. Thus began the exponential growth of technology, a growth that continues at an ever increasing rate. Naisbitt (1982) reported that, at the time of his research, technological knowledge doubled every 5.5 years. One can count on even faster progress today.

The exponential growth of technology affects all of society: communication, transportation, construction, and production. Electron-beam lithography, a communication process, is so precise it has been used to reproduce the entire *Encyclopedia Britannica* on a postage stamp. With the development of an appropriate reader, imagine the future capacity of home libraries.

Electronically enhanced infrared scopes are used to see at night. Giant telescopes and photographic emulsions are used to see into the depths of space. Radio telescopes can see to the center of the galaxy. Computer tomography and magnetic resonance imaging are used to look inside the human body. Communication technology is also pushing marvelous new frontiers, for example, the theoretical limit of today's optical fiber system is 100,000 simultaneous conversations (Perreault & Kozak, 1984).

Southern Californians make 50 million daily vehicle trips, and this is expected to rise to at least 65 million by the year 2000. Japan's magnetically levitated train may be an example of alternative futuristic terrestrial transportation. The vehicle is projected to operate at speeds over 300 miles per hour due to the use of superconductors for levitation (Perreault & Kozak, 1984).

The construction market is being impacted by new materials such as advanced polymer composites, techniques, and robotics. Modular construction, if globally accepted, will eliminate many of the common and wasteful techniques used today.

Although many additional examples may be used to demonstrate the exponential growth of technology, perhaps the rate of change is best demonstrated by citing one particular example in greater detail: composites. A composite material is a complex primary structural form that combines two or more materials to provide a desired property superior to the properties of either of the individual materials. The components of a composite do not dissolve or merge together. Instead, they act in concert (Composite materials, 1986).

Worldwide sales of advanced composites are expected to grow 15 percent annually into the next century with shipments valued above $10 billion annually). This rate of change to a new material form has also resulted in new production processes that did not exist only a few years ago: (a) reinforced reaction injection molding, (b) resin transfer molding, (c) bag molding processing, (d) automated tape laying, (e) pultrusion, and (f) filament winding. New processes are being used for new materials that are specifically designed for almost each new product.

The point is that the meta-technological effect, based on an exponential rate-of-change, produces rampant change in a variety of industries, in a variety of employment opportunities, in a variety of daily activities. Given this effect, one can only wonder what life will be like 50 years from now. Will the United States continue its comparative downward technological spiral? The U.S. has lost 20 percent of the automobile market to Japan, 33 percent of the camera market and over 50 percent of the radio market. Will this continue? The U.S.S.R. has demonstrated the ability to haul 100 tons into space compared to the obsolete U.S. Saturn which could only haul 50 tons. The U.S.S.R. launches almost 90 percent of the world's payload and has made a significant bid for the exploration of Mars (Lauda, 1987). Will the U.S. role in space exploration also decrease?

The fourth wave, which is projected to last until approximately 2045, will be based on artificial intelligence and the application of thought to electronic technology. Will the United States be a participant or an observer (Raymond, 1986)?

Societies' Utilization of Technology

Americans live in an electromechanical, digital, computational, chemical, biomedical society. Humans use technology to provide society with new capabilities and new opportunities. Technology makes obsolete certain ways of life and certain values. Technology in today's society is centralized, specialized, autocratic, threatening, and intimidating. For example, the increased use of robots that can serve and service machines and other robots may substantially increase the unemployment rolls and perhaps even increase the number of individuals on welfare. In some plants, when the first robot arrives, the workers know their time of employment is limited. It is only a matter of time till they are replaced. Anxiety sets in. Quality and productivity suffer.

Women, through the use of work-reducing devices in the home, have used technology to redefine their role in society. Technology, through contraceptives, has separated the sexual act from procreation, making the family unit only one method of ordering and obtaining such gratification in society. Technology is rapidly changing the typical family home. Technology also affects home life by providing some with increasing leisure time and also providing contemporary activities and equipment to occupy that time.

Religious pilgrimage has been made available to more people in contemporary society because of technology's impact on transportation. The television evangelist is also an integral aspect of today's technological society. Technology has had a direct impact on society's participation in politics. Not only does television provide visual contact with politicians, but governmental control of the medium could result in control of society itself.

The technologies of medicine offer great promise for society. The chance of survival of a newborn infant to late middle age has greatly increased over what it was at the turn of the century. However, the question may become, should this opportunity be extended to newborns who carry genetic defects? Who should decide (Pytlik, Lauda, & Johnson, 1985).

Economists state that the rate at which money changes hands in a society influences expenditure, thereby affecting the money supply. Technology, through high-speed computers and telecommunication systems in multinational banking institutions, has added tremendous impact to this increasing spiral thus creating a fake increase in the actual money supply which causes prices to rise, thereby decreasing the value of the dollar on the world market (Pytlik et al., 1985).

Whereas the diminishing industrial society of the past was based on electricity, the post-industrial age is based on electronic, computer, lasers, CAD/CAM/CIM, and other technological systems that stretch the imagination and our capability. Also referred to as the information age, the thrust towards a post-industrial society will be built on efficiency, conservation, quality, and flexibility. Quantity, the prime mover of the industrial age, may shortly be forgotten.

Understanding Technology

Technology can be defined as the systems and objects or artifacts that are created using knowledge from the physical and social spheres of activity. These systems and artifacts are typically designed to have a purpose which affects the activities and organization of society. Technology is part of a process which we do to modify the environment in response to human needs (Friedman, 1980).

Is it becoming necessary for all people to understand technology if they are to function as citizens? A Harris (1970) poll defined literacy as: "…the ability to respond to practical tasks of daily life" (p. 10). Anyone who understands technology is able to apply knowledge and also able to perform tests using tools, machines, materials, equipment, the exponential growth of technology, the varied purposes of education, and individual perspectives, not all persons need to understand technology to the same degree.

Modern technological solutions seem to create a sense of uneasiness or a sense of frustration that early technological knowledge did not. This attitude of dread and rejection has drastic effects on the acquisition of technological knowledge. If people are disheartened by something, they typically do not learn about it; they definitely do not attempt to become literate about it (Brockway, 1987).

Technology is a body of knowledge and capabilities that is distinct from others. Often it proceeds, rather than follows, scientific understanding (Brockway, 1987). Because of a mistaken tendency to equate technology with computers, a caveat is in order. Advocates of computer literacy must learn their pets' (computers) rightful place in a technological society. Computers are but one segment of the world of technology; technology is not a part of computing. Given this relationship, the concept of technology contains computer literacy (Dyrenfurth, 1984).

THE CHALLENGE FOR EDUCATION

> Man has before him the possibility of a new level of greatness, a new realization of human dignity and effectiveness. The instrument which will realize this possibility is that kind of education which frees the mind and enables it to contribute to a full and worthy life. To achieve this goal is the high hope of the nation and the central challenge to its schools (Educational Policies Commission, 1961, p. 21).

> One of the fundamental truths of this new age of technology is that it is not possible to select, design, operate appropriately, or control technical systems without a thorough knowledge and understanding of the behavior of the systems and their relation to human beings, their society, and the environment. The design and operation of the new technical means required for our transfer to a sustainable and preferable future mandates a highly educated populace (DeVore, 1987, p. 70).

The challenge for education is real, and currently the successes are questionable. Seventy-five percent of high school youth never graduate from college, and over 3,000 students drop out of high school each day in the Unite States (Thomas, 1987). Forty percent of the students leaving high school cannot read beyond the ninth grade level (Lauda, 1987). More than 30 recently issued reports prepared by task forces, commissions, and individuals demand that urgent attention be given to American schools (Thomas, 1987).

Purposes of American Schools

The American people have traditionally regarded education as a means for improving themselves and their society. The Commission on the Reorganization of Secondary Education proposed, in 1918, a set of seven cardinal objectives for the school: (a) health, (b) command of fundamental processes, (c) worthy home membership, (d) vocational competence, (e) effective citizenship, (f) worthy use of leisure, and (g) ethical character. The Educational Policies Commission developed, in 1938, a number of objectives for the school under four major headings: (a) self-realization, (b) human relationships, (c) economic efficiency, and (d) civic responsibility. Fifty years later, these purposes of education are still appropriate (Educational Policies Commission, 1961).

Domains of Learning

Educational psychologists categorize learning into three domains: cognitive (knowing), affective (feeling), and psychomotor (doing) (see Figure 8-1). Shemick (1985) lists the appropriate levels within each domain. Education programs must permit every student to experience learning in all domains and at all levels if learning is to be meaningful.

Level	Cognitive	Affective	Psychomotor
1	Recognition/Recall	Receive	Observing
2	Comprehension/ Interpretation	Respond	Imitating
3	Application	Observe/Value	Manipulating
4	Analysis/Synthesis	Organize	Performing
5	Evaluation	Characterize	Perfecting

Figure 8-1. Domains of Learning

The Ability to Think

The traditionally accepted obligation of the school to teach the fundamental processes developed by the Commissions in 1918 and 1938, is clearly directed toward the development of the ability to think. The central purpose of the school, which runs through and strengthens all other educational purposes and is the common thread of education, is therefore the development of the ability to think. A person who thinks can understand the importance of the ability to do so. It is the thinking person who can bring all valid purposes into an integrated whole. Rationality is a means as well as an end (Educational Policies Commission, 1961).

Education must be infused with the process of thinking and the attitude of thoughtfulness. Choice as to methods and means of developing the ability to think is in the hands of the individual instructor. It is crucial, therefore, that the instructor possess a thorough knowledge of the material to be taught, mature mastery of a variety of teaching procedures, an understanding of students, and the quality of judgment to blend all in making decisions (Educational Policies Commission, 1961).

Education About Technology

Technological knowledge is one of the primary hallmarks of the American culture. If knowledge is power, then those with technological knowledge will hold the power of the future (Brockway, 1987).

Technology education, as a name for a program area of study, evolved from discussion (circa 1970) between Dr. James Harlow, President of West Virginia University and Dr. Paul DeVore. It also was the title given to a curriculum area designed to teach about our technological past, present, and future. Since that time, the term **technology education** has been increasingly accepted and used.

Recent Historical Developments and Influences

A variety of events has served to promote the understanding and acceptance of technology education as a necessary component of a formal education. In 1972 Paul DeVore made a major contribution to this effort in his work "Education in Technological Society." Eastern Illinois University, in 1976, established the first undergraduate degree in technology education under the leadership of Donal P. Lausa. Since beginning in 1980, more than ten symposia and six national technological literacy conferences focusing on issues related to technology education have been held throughout the country.

The acceptance of any educational program, however, depends upon the successful development of appropriate goals, objectives, rationale, philosophy, curriculum, and methodology. One of the most significant events was the development of a comprehensive philosophy and rationale for the study of technology as a result of the Jackson's Mill Industrial Arts Curriculum Project in 1981. The curriculum model that resulted from Jackson's Mill gives validity and direction to the selection of content to be studied within a curriculum area titled technology education. The intent is that content should be derived from the universal technical systems of communication, transportation, construction, and manufacturing (Snyder & Hales, 1981).

A number of curriculum projects with a focus on technology followed Jackson's Mill and each made unique and significant contributions. To name but a few: Occupational and Practical Arts Futuring Project, New York State Education Department (1981); Industry and Technology Education Project, Technical Foundation of America (1982); and The Illinois Plan (1984). In 1984, the American Industrial Arts Association published their Professional Improvement Plan with goals and directives toward 1986 and a commitment for a change toward technology education. In 1985, the American Industrial Arts Association changed its name to the International Technology Education Association. The First World Assembly on Technology Education, in 1988, at Norfolk, Virginia, had sixteen countries participating. The fifth PATT (Pupils' Attitude Toward Technology) Conference will be held in 1991 at Eindhoven, Netherlands. This week long conference has presentations delivered by individuals from throughout the world including eastern block countries.

All of these efforts reinforce the progress that has been made at local, state, national, and international levels toward the development and implementation of technology education. Historians will tout technology education as one of the disciplines that provided the initial thrust for the integration of knowledge (Lauda, 1987).

Technology Education in the Public Schools

Approximately 60 percent of the state are engaged in curriculum work to upgrade technology education programs (Jones & Wright, 1987). If properly taught, most public school subjects, including technology education, can help the student to:

- Know and appreciate the importance of technology;
- Uncover and develop individual talents;
- Apply problem-solving techniques;
- Apply other school subjects;
- Apply creative abilities;
- Deal with forces that influence the future;
- Adjust to the changing environment; and
- Make informed career choices (ITEA, 1985).

However, technology education, in particular, develops the students' capability to:

- Apply tools, materials, processes, and technical concepts safely and efficiently; and
- Become a wiser consumer (ITEA, 1985).

Figure 8-2 is a model for the curriculum structure of technology education at the three levels of public school education: elementary school, middle school, and high school. Technology education is a fundamental and basic area of study suitable for all students at all grade levels. As Maley (1987) stated, "A critical school-based issue is to establish technology education as an educational staple in the diet of all students in our schools." (p. 20)

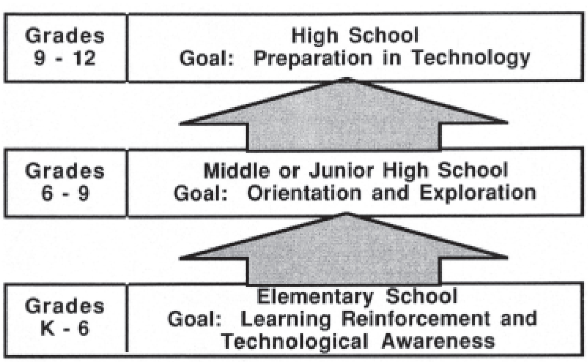

Figure 8-2. Curriculum Structure for Technology Education. (ITEA, 1985, p. 25)

Elementary School Technology Education

"The aim of the elementary school technology education program is to develop a first-hand understanding of the technology that supports daily life" (Peterson, 1986, p. 47). In other words, how does technology work and how does it affect people? A technology-based elementary school program prepares students to understand their culture and the culture of others. Technology education at the elementary school level is usually taught by the regular classroom teacher and is incorporated into units dealing with other issues of learning.

Middle School Technology Education

Technology education at the middle school level is exploratory in nature. It is at this level that content is focused around the technological system areas of communication, transportation, manufacturing, and construction. Although typically focused on the four technological areas, the curriculum is broadly presented. It is recommended that all students at the middle school level take technology education (ITEA, 1985).

	6th Grade	7th Grade	8th Grade
Exploratory	• Recognize wide range of student interests • Provide variety, flexibility of materials used & concepts learned	• Students explore production, power, & transportation & communication systems	• Study of variety of materials and the processes of working with them. Humans use materials to improve their life on earth.
Broad & Fundamental	• Develop understanding that technology is human-created • Answer, "What is technology?" • Conceptually based	• Systems of technology, power & transportation, communication, processing, manufacturing, construction • Conceptually-based	• Elements of technology operate in certain ways to result in consequences for humans • Conceptually based

Interdisciplinary	• Study of technology can reinforce learning in social sciences, humanities, natural sciences	• Technology-Science-Humanities are interdependent, each contributes and depends upon the other	• Science of materials Physics of processes Social impact of technology • Consequences of technology
Vertically Integrated	• Transition from learning reinforcement function of the elementary school study of technology to more narrow specialized study	• With basic understanding of the nature of technology acquired in grade 6, study can begin to be more specific • The study of technological systems	• Increasing specificity • Preparation to enter high school curriculum
Understanding	• Close pupil-teacher contact • Begin transition from elementary school • Fast-paced, active	• Increasing departmentalization • Increasing student responsibility • Activity-oriented exploration	• Begin transition into high school • Increasing departmentalization • Recognize developing & changing student interests

Figure 8-3. Articulation in industrial/technology based education in the middle school (Bame, 1986, p. 74)

Grades	Recommended Courses	Type of Course 8-9
8-9	Communications systems Construction Systems Manufacturing Systems Transportation Systems	Elective course, each a semester in length 6-7
6-7	Introduction to Industrial and Technological Systems	Required course, a semester in length

Figure 8-4. Recommended courses in technology education for the middle school or junior high school (*ITEA*, 1985, p.26).

According to Bame (1986), a middle school technology education curriculum should be: (a) exploratory, (b) aimed at understanding, (c) broad and fundamental, (d) interdisciplinary, and (e) vertically integrated (see Figure 8-3). Recommended courses in technology education for the middle school level are illustrated in Figure 8-4.

High School Technology Education

The intent to a high school technology education program should be to provide students with a plan of study to help them become knowledgeable and wiser decision makers about the technological environment in which they live.

Technology education at the high school level should include course offerings from each of the systems or sub-systems used to encompass technology. Jackson's Mill-based programs would use communication, construction, manufacturing, and transportation for example. These might include courses in graphic communication, media communication, electronic communication, construction planning and design, constructing and servicing structures, electro/mechanical systems, materials and processes, designing manufacturing processes, production systems, transportation planning and design, and/or transportation systems.

According to the International Technology Education Association's *Technology Education: A Perspective on Implementation* (1985), as a result of technology education at the high school level, students will:

1. Experience the practical application of basic scientific and mathematical principles;
2. Make decisions regarding postsecondary technology careers, engineering programs, or service-related fields;
3. Make decisions with regard to advanced vocational education programs;
4. Gain an in-depth understanding and appreciation for technology in our society and culture;
5. Develop basic skill in the proper use of tools, machines, materials, and processes; and
6. Solve problems involving the tools, machines, materials, processes, products, and services of industry and technology (p. 27).

Technology Education in Colleges and Universities

Technology education courses allow colleges the opportunity to keep a strong foothold in traditional humanities while relating them better to the world in which we live. Faculty and administrators at Lehigh University have dedicated ten years to the development of the Science, Technology and Society Program which they believe prepares students to live and work in a highly technological society. Recognizing the implications and interactions of science and technology on modern life, the faculty at the Massachusetts Institute of Technology have also established a Program in Science, Technology and Society to provide both engineering and non-engineering majors with a social context from which to view scientific and technological activities and events. St. Louis University administrators and faulty have developed the Man, Technology, and Society Program which they believe helps prepare students for the 21st century. The program provides students with an interdisciplinary understanding of technology's role and influence in American culture.

The Department of Technology and society (DTS) at the State University of New York (SUNY)—The College of Stony Brook was established as an independent entity in 1978. Any social or philosophical issues that arise from class discussions are considered within the context of technological feasibility. Approximately 75 percent of all SUNY—Stony Brook undergraduates sign up for at least one DTS course. By learning technological skills and proper problem-solving attitudes and procedures in a Patterns of Problem Solving course, students at the University of California, Los Angeles devise solutions for both personal and world problems. The University of Wisconsin—Madison College of Engineering offers seniors and graduate students a Sociotechnical Systems Design Program designed to integrate engineering and technology with liberal arts learning (Friedman, 1980).

Technology Education Teacher Preparation Programs

In the 1950s and 1960s many teacher preparation colleges became state universities with missions that transcended teacher preparation. Throughout the 1970s, enrollments in technology teacher education declined equally dramatically (Erekson, 1987). With unfortunately few exceptions, technology teacher education programs today are virtually being squeezed out. Some technology teacher education programs are absorbed into industrial technology programs. But others are just closed. In addition, students who enter technology education programs often transfer to industrial technology due to the many advantages such as starting salary, employment opportunities, and occupational status (Jones & Wright, 1987).

Maintaining a strong, quality-driven public school technology education program begins with the preparation of competent and caring instructors. However, what are competent instructors? If prospective technology education instructors are prepared for available jobs, then the status quo is perpetuated; if they are prepared for non-traditional programs, such jobs may not be available. The challenge facing teacher educators is to design a technology education program that is future oriented yet provides its graduates with the ability to teach technology education in the existing school environment (Kozak, 1982). If technology teacher educators act responsibly and responsively to educate future generations of instructors, programs will be designed that will meet the needs of tomorrow. Courses that are even questionably irrelevant in 1990 will definitely be so in the future (Seidman & Kozak, 1983).

With the escalating thrust toward technology-based programs at the public school levels, major changes in teacher preparation programs are necessary to prepare instructors who have a comprehensive understanding of the content, organization, philosophy, and methodology of such a program. However, in many instances program changes at the college/university level are lagging behind curriculum changes taking place in the junior and senior high schools. Perhaps at no other time in history has there been a greater need for teacher preparation programs to be pro-active rather than reactive. Strong leadership and direction is extremely crucial in this formative period of school and university program development.

What changes lie ahead? What are some of the predictions for technology teacher education programs? Erekson (1987) predicts that technology instructors will be required to develop competence in mathematics, sciences, computer science, computer applications, economics, labor relations, industrial psychology, sociology, history of technology, and languages. Jones and Wright (1987) predict that regional technology teacher education programs, rather than multiple programs per state, may become a reality. Lauda (1987) indicates that he visualizes teacher education programs in science education and technology education merging into a single entity.

As Maley (1987) points out: "There is a need, as well as a challenge, to educate a new breed of teachers who can deal with the issues related to technology education. This will go beyond the mere capability of teaching craft-related content." (p. 14). According to Henak & Barella (1986), this challenge requires avoiding a common curriculum development mistake—namely that of developing control-oriented, teacher directed programs.

The 35th Yearbook (Jones & Wright, 1986) provided a study of undergraduate technology teacher preparation in terms of the professional and technical sequence. These authors will also use that breakdown. In fact, it seems most appropriate to summarize that information.

Professional Sequence

The professional sequence of courses in a technology teacher preparation program should provide the opportunity for students in the program to accomplish six things:

- Develop a personal theory. A personal theory provides future teachers a rational basis for their professional activities. Its development hopefully forces a theory that is comprehensive, internally consistent, and individually accurate.
- Use instructional technology. The use of instructional technology refers to the efficient and appropriate practice of teaching.
- Develop a value system. This is essential in a world that is based on technological development. A strong value system will help teachers "view technical progress more in terms of bettering the quality of life than in simply producing something to make a profit" (p. 149).
- Develop a futuristic orientation. This will make it possible for future teachers to consider alternatives and make decisions regarding those alternatives if and when they become reality.
- Become independent lifelong learners. Technology education teachers need to understand the continually changing nature of the curriculum they will be teaching. Along with that understanding is the need to develop ways in which to become continually educated about those changes, their nature, and their ability for impact.
- Develop a positive self-concept. A positive self-image will help a technology education teacher, or any teacher, succeed in the classroom (Henak & Barella, 1986).

Technical Sequence

It is almost impossible for any one person to be knowledgeable in all areas of technology due to its vastness and rapidity of change. Therefore, technology education instructors will have to have a basic understanding of the broad range of technologies. The technical skills of technology education instructors will need to be transferable so they can be applied in a variety of situations (Thomas, 1987). To achieve this end, elimination of the typical skill development courses needs to be considered. Instead, technology instructors should possible be required to serve technology-based internships in business and industry. With this de-emphasis on university-centered skill development, the major thrust of the program could be devoted to curriculum understanding, methodology development, and skill transfer ability (Erekson, 1987).

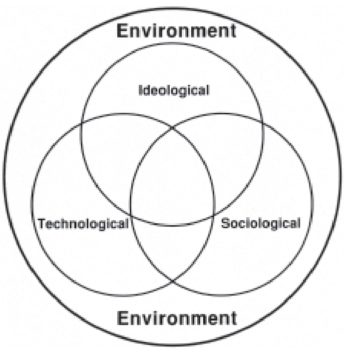

Figure 8-5. The human adaptive systems of ideological, technological, and sociolocial work together in a human-made and natural environment

The technical sequence developed for the study of technology education is derived from the human adaptive systems as identified by DeVore (1980) and subsequently the Jackson's Mill Curriculum Project (see figure 8-5). Within the technological component of the human adaptive systems are the technical means by which we are able to extend the human potential. These technical means can be clustered into the systems of communication, construction, production, and transportation.

Technology education teacher preparation program content is based on the need for future teachers to become technologically literate and in turn, be able to develop the technological literacy of their students. One overview of a possible curriculum configuration to meet this end may be the scope and sequence model for a four-year technology-based teacher-preparation program indicted in Figure 8-6 (Helsel & Jones, 1986).

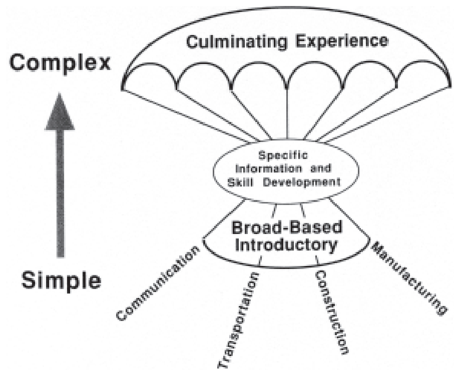

Figure 8-6. Scope and Sequence Model (Helsel & Jones, 1986, p. 175.

Deriving a curriculum sequence from this model suggests beginning with courses that provide an overview of the technological systems. The narrow middle sequence is made up of courses dealing with specific information about each system as well as skill development. The broadening of this model from the specific narrow middle directs the curriculum toward courses that allow the future teacher to explore the interrelationship of the specifics. These courses reinforce adaptation of content to a variety of situations and require the utilization of problem-solving abilities.

TECHNOLOGY EDUCATION CURRICULUM STRUCTURE

Technology education curriculum content should have intrinsic merit that would stand up under the scrutiny of classical scholars (Friedman, 1980). Technology education, as a discipline, denotes a field of study in the same way that geology, biology, or anthropology are used (Dyrenfurth, 1984). If it is agreed that change is basic to technology, then it should also be accepted that technology education is a constantly changing curriculum with certain elements periodically being eliminated and others being added (Pullias, 1987).

Content

The identifiable domains and capabilities for a technologically competent individual may be stated as the possession of a broad technological knowledge together with the required attitudes and physical abilities to implement that knowledge in a safe, appropriate, effective, and efficient manner. Therefore, attaining technological competence involves each of the domains of human behavior. Prior to developing an instructional strategy, the cognitive, affective, and psychomotor skills that are to be taught must be defined and their interrelationships specified.

Cognitive development has been given the greatest attention throughout the history of formal education. Virtually all school progress is defined in terms of grades, subject areas, and clock hours, and is measured in terms of how much a student knows and is able to indicate through examination. For most educators it is relatively easy to define things to know and ideas to conceptualize. It is imperative that identifiable cognitive capabilities be included in a technology education program.

In addition to the cognitive domain, technologists also find themselves concerned with the affective domain. As technology forces new social, cultural, and economic relationships, technology educators must consider even more seriously the issues of values of technology on society. Affective development involves positive and/or negative feelings, attitudes, interests, appreciations, values, morals, character, and personal and social adjustment. Identifiable affective capabilities must be included in a technology education program.

Students learn technology by actually experiencing the activities and processes of a technological society. The psychomotor domain is concerned with movement behaviors: manipulative and motor skills, and arts requiring neuromuscular coordination. Therefore, when on performs purposeful psychomotor activities, they should involve the coordination of the cognitive, affective, and psychomotor domains. It is imperative that key psychomotor capabilities be included in a technology education program.

The Jackson's Mill Curriculum Project (Snyder & Hales, 1981) provided the profession with a sound theoretical basis for curriculum content. Scope and sequencing models have provided ways in which courses within that content might be organized. It therefore becomes necessary to provide organizational strategies for the content within individual courses.

The Systems Approach

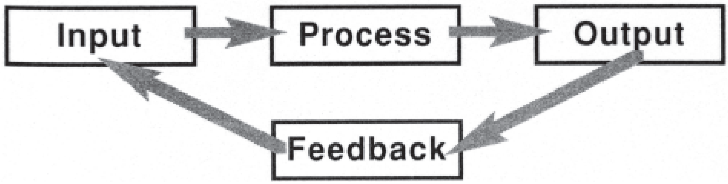

Figure 8-7. A Systems Model.

The systems approach to organizing content is based on the model of input→process→output→feedback (see Figure 8-7). When the systems model is used to develop content for courses within a technological sequence, the replacement of terms within the model results in a technological systems model (Jones, 1983). Input is replaced with Resources, process with technical process, output with applications, and feedback with technological impacts (see Figure 8-8).

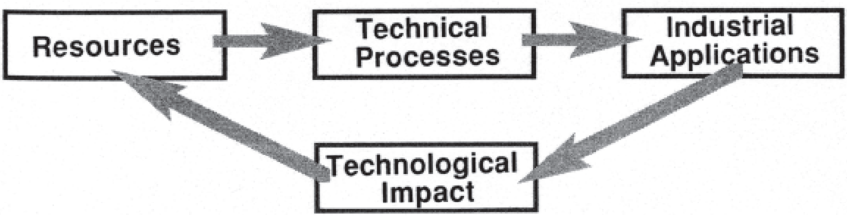

Figure 8-8. Technological systems model. (Jones, 1983.)

Within the context of this model, resources refer to the inputs to the system such as tools, materials, people, and money. Processes are the ways in which the resources are used. Application is how and where the processes are used, and the impacts are the effects of the system on the environment and/or society.

Utilizing the technological systems model to derive content requires adding specifics to each of the model components. It is these specifics that make up course content. An example of content as it fits into this model is shown in Figure 8-9. It is important to keep in mind that Figure 8-9 is merely a sampling of the content for a given course. It is, however, indicative of how the model is used to organize that content.

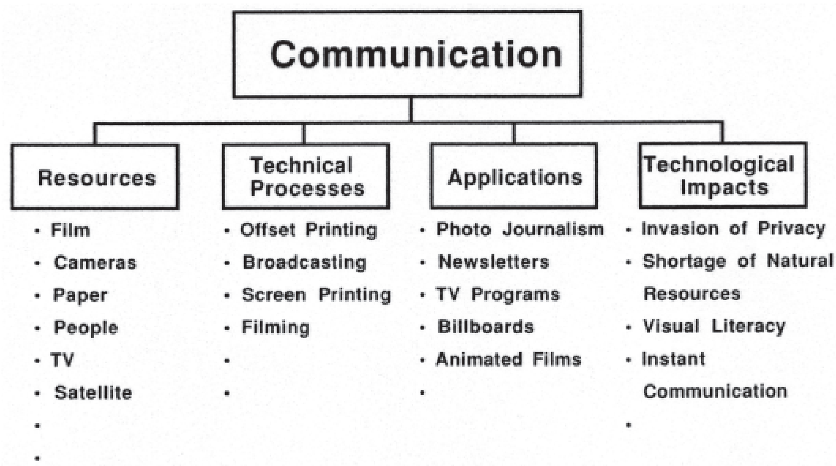

Figure 8-9. Course Content for Communication, derived using the technological systems model.

Integrating the Systems

As Jones (1988) points out, a **complete** job of teaching the technological systems cannot be accomplished without teaching each system in relation to every other. For example, production systems do not exist in total isolation from communication, construction, and transportation systems. While selected portions could be taught in isolation, to teach one of the systems as a total concept, the other three systems must b included.

Jones (1988) goes so far as to suggest that "Technology education teachers should not try to separate the systems" (p. 107). Integrating the systems is the natural process of teaching technology education. It does not require special preparation or inclusion on the part of the teacher; it is already there, neatly tucked into all technology-based curricula (Jones, 1988).

What appears to be one of the easiest places to assure integration of the systems is within the application component of the technological systems model. For example, when studying communication with respect to the technological systems model, integration of the systems can be accomplished by studying the way in which various communication processes are applied within transportation, production, and construction systems.

Methodology

Concepts develop as a result of perceptible instances (experiences). Words give these concepts a name. Without experiences, it is extremely difficult to learn any type of information. Whereas direct experience is the most concrete level of presenting information, language or verbal symbols are the most abstract level (Scarborough & Blankenbaker, 1983). If students are taught to-learn-how-to-learn-use, rather than how to use technological innovations, then not only will they have the direct experience but, in addition, they will be more able to transfer the learning process to technological innovations of the future (Kozak, 1982).

The technology education laboratory dedicated to the transfer of learning should truly be laboratory. The equipment should be easily mobile since the entire laboratory needs to be designed for flexibility. Tabletop technology and many computers are integral components. The mobility of the equipment permits the laboratory to be constantly configured to facilitate the students' pursuit of learning objectives (Pullias, 1987).

SUMMARY

The exponential growth of technology is affecting every aspect of life, not only the industrial component of society. To use the example previously cited in this chapter, today's students need to know not only how composite structures are produced and how to make projects from them, they also need to know how to live with composites, how composites have become an integral part of their everyday life, and the effects composites will have on their future. However, understanding technology does not imply only a global understanding of the technological world, but also includes a knowledge of, and capability with, technology in the individual's environment—coping with an evolving society.

Technology education must be the preparation of people to exist in, and to relate to, a rapidly changing world. Technology educators must include all levels within the domains of learning in their teaching. Technology educators must also develop in students a cohesive philosophy of technology, and an appreciation of the interrelatedness of all technological systems.

REFERENCES

(1981). *Occupational and Practical Arts Futuring Project.* Albany, NY: New York State Education Department.

(1984). *The Illinois Plan for Industrial Education.* Springfield, IL: Department of Adult, Vocational and Technical Education.

(1986, March). Composite materials. *The Technology Teacher,* 43(6), 15–21.

Bame, E. A. (1936). Middle/junior high technology education. In R. E. Jones & J. R. Wright (Eds.), *Implementing Technology Education,* 35th yearbook of the American Council on Industrial Arts Teacher Education, (pp. 70–94). Bloomington, IL: McKnight.

Brockway, J. P. (1987). Technology & the liberal arts: Are we producing technopeasants? In *Technological Literacy: The Roles of Practical Arts and Vocational Education,* international symposium proceedings, (pp. 39–45) May 13-15. Columbus, OH: The Ohio State University.

Davis,G . B. (1980) CAM: A key to improving productivity. *Modern Machine Shop,* 53(4).

DeVore, P. W. (1972, May). *Education in technological society: Access to tools.* Mimeo. Morgantown, WV: West Virginia University.

DeVore, P. W. (1980.) *Technology: An introduction.* Worcester, MA: Davis.

DeVore, P. W. (1987). 2030 A.D.: Critical paths to 2080 A.D. In M.R. Kozak & J. Robb (Eds.), *Technology Education Symposium IX,* proceedings, (pp. 63–74). Denton, TX: North Texas State University.

Dyrenfurth, M. J. (1984). *Literacy for a technological world.* Information Series No. 266. Columbus, OH: The National Center for Research in Vocational Education. ERIC ED 241715.

Dyrenfurth, M. J. (1987).International perspectives on technological literacy. In *Technological Literacy: The Roles of Practical Arts and Vocational Education,* international symposium proceedings, May 13-15, (pp. 19–37). Columbus, OH: The Ohio State University.

Educational Policies Commission. (1961). *The central purpose of American education.* Washington, DC: National Educational Association.

Erekson, T. L. (1987). 2030 A.D.: The role of the technology teacher educator. In M.R. Kozak & J. Robb (Eds.), *Technology Education Symposium IX,* proceedings, (pp. 37-39). Denton, TX: North Texas State University.

Friedman, E. A. (1980, December). Dimensions of technological literacy in liberal education. *Forum,* 3(3).

Harris, L., et al. (1970). *Survival literacy study.* New York: Louis Harris and Associates.

Helsel, L. D., & Jones, R. E. (1986). Undergraduate technology education: The technical sequence. In R. E. Jones & J. R, Wright (Eds.), *Implementing Technology Education,* 35th yearbook of the American Council on Industrial Arts Teacher Education, (pp. 17l–200). Bloomington, IL: McKnight.

Henak, R. M., & Barella, R. (1986). Undergraduate technology education: The professional sequence. In R. E. Jones & J. R Wright (Eds.), *Implementing Technology Education,* 35th yearbook of the American Council on Industrial Arts Teacher Education, (pp. 138–170). Bloomington, IL: McKnight.

International Technology Education Association. (1985).*Technology education: A perspective on-implementation.* Reston, VA: ITEA.

Jones, R. E. (1983, Winter). Implementing a state plan for industrial education curriculum model. *Illinois Industrial Educator,* 2(4), 8–10.

Jones, R. E. (1988). Integrating the systems of technology approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional Strategies For Technology Education,* 37th yearbook of the Council on Technology Education, (pp. 99–1091). Mission Hills, CA: Glencoe.

Jones, R. E., & Wright, J. R. (1987). The symposium: Historical perspective and expectations. In M.R. Kozak & J. Robb (Eds.). *Technology Education Symposium IX,* proceedings, (pp. 3-7). Denton, TX: North Texas State University.

Jones, R. E., & Wright, J. R. (Eds.). (1986). *Implementing technology education.* 35th yearbook of the American Council on Industrial Arts Teacher Education. Bloomington, IL: McKnight.

Kozak, M. R. (1982, Spring). The evolving profession. *The Journal of Epsilon Pi Tau,* 8(1).

Lauda, D. P. (1987). Impact of technology: A travel through time. In M.R. Kozak & J. Robb (Eds.), *Technology Education Symposium IX,* proceedings, (pp. 47-52). Denton, TX: North Texas State University.

Maley, D. (1987). Issues and trends in technology education. An unpublished manuscript. College Park, MD: Author.

Myers, N. (Ed.). (1984). *GAIA: An atlas of planet management.* Garden City, NY: Anchor Press.

Naisbitt, J. (1982). *Human capital: The profitable investment.* Technology series, No. 19. St. Paul, MN: Control Data Corp.

Parker, T. (1985). *In one day.* Boston: Houghton Mifflin.

Perreailt, R. & Kozak, M. (1984, May/June). 1984 revisited. *Industrial Education,* 73 (5).

Peterson, R. E. (1986). Elementary school technology education programs. In R. E. Jones & J. R. Wright (Eds.), *Implementing Technology Education,* 35th yearbook of the American Council on Industrial Arts Teacher Education, (pp. 47–69). Bloomington, IL: McKnight.

Pullias, D. (1987). 2030 A.D.: Role of the technology education classroom instructor. In M. R. Kozak & J. Robb (Eds.), *Technology Education Symposium IX,* proceedings, (pp.57-59). Denton, TX: North Texas State University.

Pytlik, E. C., Lauda, D. P., & Johnson, D.L. (1985) *Technology, change and society* (revised). Worchester, MA: Davis.

Raymond, H. A. (1986, September/October). Management in the third wave. *The Futurist.*

Scarborough, J. D., & Blankenbaker, E . K. (1983). *Technological literacy: The language dimension.* Monograph. Reston, VA: American Industrial Arts Association.

Seidman, S. A., & Kozak, M. R. (1983, Spring). To the year 2033: The impact of high technology on teacher education. *Texas Teacher Education Forum,* 8(1).

Shemick, J. M. (1985). The perceptual and psychomotor domain: An overview. In J. M. Shemick (Ed.), *Perceptual and Psychomotor learning in Industrial Arts Education,* 34th Yearbook, American Council for Industrial Arts Teacher Education. Peoria, IL: Bennett & McKnight.

Snyder, J. F., & Hales, J. A. (1981). *Jackson's Mill industrial arts curriculum theory.* Charleston, WV: West Virginia Department of Education.

Thomas, J. C. (1987). Technology education: The appropriate threads for a complex tapestry. In *Technological Literacy: The Roles of Practical Arts and Vocational Education,* international symposium proceedings, May 13 -15, (pp. 175–178) Columbus, OH: The Ohio State University.

Curriculum

Section VI

STANDARD 6—CURRICULUM
Technology teacher education program candidates design, implement, and evaluate curricula based upon Standards for Technological Literacy.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 6. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Identify appropriate content for the study of technology at different grade levels. • Integrate technological curriculum content from other fields of study. • Identify curriculum and instructional materials and resources that enable effective delivery when teaching about technology.
Performance Indicators:
• Engage in long-term planning that results in an articulated curriculum based on Standards for Technological Literacy for grades K-12 or equivalent. • Design technology curricula and programs that integrate content from other fields of study. • Improve the technology curriculum by making informed decisions using multiple sources of information. • Incorporate up-to-date technological developments into the technology curriculum. • Implement a technology curriculum that systemically expands the technological capabilities of the student.
Disposition Indicators:
• Demonstrate sensitivity to cultural, ethnic diversity, special needs, interest, abilities, and gender issues when selecting, designing, or evaluating curriculum and instructional materials.

Restructuring the Technology Teacher Education Curriculum

Chapter 9

Rodney L. Custer
Illinois State University

R. Thomas Wright
Ball State University

51st CTTE Yearbook, 2002

In a recent report on the role of standards as a catalyst for educational reform issued by the National Research Council (NRC), the assertion is made that significant improvement in student learning is "unlikely until teachers are educated in ways that enable them to implement and teach curricula that are consistent with the vision, goals, and content of the national standards" (NRC, 2000, p. 18). Viewed from this perspective, standards assume a more critical role than simply identifying, clarifying, and structuring the content knowledge of a discipline, as if that were a simple matter. Rather, before meaningful change can occur at the K-12 level of implementation, teacher education programs must engage in critical and honest reflection about how well they are addressing national standards.

Over the next few years, technology teacher educators will decide the extent they agree or disagree with this assertion—that educational reform at the K-12 level is fundamentally grounded in seriously addressing *Standards for Technological Literacy: Content for the Study of Technology (Standards for Technological Literacy)* (ITEA, 2000). At one level, the issue is curricular (i.e., configuring courses and student activities to align with standards). Viewed more broadly, serious engagement with the standards has the potential of triggering fundamental reform of how technology teacher education is configured and delivered. As indicated in previous chapters, implementing the standards will include changing the teacher education curriculum, but it is only one component for implementing a technology based education system. From this perspective, the stakes are much higher and the risks associated with significant change are very real.

The National Commission on Teaching and America's Future (NCTAF), in a report critical of teacher education in America, reported that the view persists that anyone can teach, especially if they have adequate content knowledge (NCTAF, 1996). The report goes on to voice the view, shared by many, that "teacher preparation programs contribute little to the production of qualified teachers and high-quality teaching" (NCTAF, 1996). Some of these same perceptions, and misperceptions, are also apparent in technology education. Within technology education, the perception (and perhaps the reality) persists that the profession is strong on activities and limited in terms of content knowledge. The profession is in an exciting, and perhaps even terrifying, period of time when many teachers are uncertain of their grasp of content knowledge as well as their ability to employ the kinds of new teaching methods required to meet the standards. Given this situation, it is very important that technology teacher education programs be equipped to have a major effect on students who are preparing to become technology education teachers.

Thus, the challenge for technology teacher educators and the purpose of this chapter extends beyond how to teach pre-service educators how to teach the content contained in *Standards for Technological Literacy* in their K-12 classrooms. Rather, it is important that the field think more broadly about curricular reform, including such thorny challenges as integrating technology content across disciplines, stimulating students to engage in meaningful reflection on technological activities, and equipping students to cope with the inherently dynamic and expansive nature of technology.

It is important to note at the outset that the authors' purpose throughout this chapter is to raise, frame, and clarify curricular issues that, in our judgment, must be addressed as a function of what *Standards for Technological Literacy* contains. The authors have attempted to refrain from prescribing how our colleagues at various teacher education programs should respond in making their curricular decisions. Those are local decisions and the profession stands to benefit by the development of a variety of creative implementation strategies and models. The authors' charge is to raise the issues and stimulate dialog.

COMPETENCE FOR TECHNOLOGY TEACHERS

At a basic level, the preparation of technology education teachers involves three primary dimensions: knowing, doing, and valuing. These are not new and a strong element of each is woven throughout the standards. Throughout the history of the field, the profession has in various ways concentrated on all three, with arguably a primary emphasis on the "doing" component. If successful, *Standards for Technological Literacy* will cause the profession to rethink these dimensions in several important ways. First, these standards contain material that redefines and expands what it is that technology educators have traditionally known, done, and valued. All three dimensions have been dramatically expanded to include content that may be relatively new to many teachers and teacher educators. It will take time, hard choices, and considerable professional development to conceptualize and craft new curriculum materials capable of delivering this expanded body of content.

A second shift has to do with an increased emphasis on the knowing (content) dimension. It is important to recognize that *Standards for Technological Literacy* is inherently designed to define the essential content knowledge of technology education. *The National Science Education Standards* by NRC (1996) and American Association for the Advancement of Science (AAAS) *Benchmarks for Science Literacy* (1993) and *Principles and Standards for School Mathematics* (2000) by National Council of Teachers of Mathematics (NCTM) were specifically intended to identify, clarify, and structure the content knowledge of their respective fields. They both raised and attempted to address the question, "What, in this modern world, do students need to know about science and mathematics?" To a lesser extent, both subject matter areas addressed broader learning and pedagogical issues. But the primary focus was on content. *Standards for Technological Literacy* also contains a strong emphasis on content. What is the base content knowledge of technology? What do all citizens in a technological culture need to know about technology? What does it mean to be a technologically literate person? The profession has and will continue to ask, "What do students need to be able to do with and value about technology?" But, the standards were developed on the premise that there is such a thing as a body of technological knowledge and that technology is more than the application of knowledge from other subject matter areas (e.g., mathematics and science).

As such, technology teacher education must continue to concentrate on the knowing, doing, and valuing aspects of technology. What must now be addressed is how to best equip new teachers to deliver an expanded (and perhaps unfamiliar), standards-based body of content and activity. A significant part of this challenge is to do so in a way that maintains an appropriate balance among the three. It simply will not do to recast the study of technology into a passive, intellectual exercise devoid of active engagement with a variety of technologies. At the same time, *Standards for Technological Literacy* will force the profession to confront a tendency to engage in activities apart from meaningful and focused learning. Also, it is quite likely that this will force us to engage in increased levels of collaboration with other academic disciplines in ways that may be threatening and challenging.

FUNDAMENTAL KNOWLEDGE BASE FOR THE STUDY OF TECHNOLOGY

The first ten technology standards deal generally on defining the base content knowledge for the study of technology. More specifically, three general areas of concentration are identified and developed in detail. These include a fundamental understanding of The Nature of Technology, Technology and Society or its role and function in society, and Design or the elements and essence of design and problem solving. The authors will address each of these three categories. In each case, the authors will attempt to pinpoint key curricular issues that in our judgment need to be addressed in order to implement the standards.

The Nature of Technology

The first three initial standards focus on The Nature of Technology. Technology teacher education curricula must include components that cause students to think in depth about what is meant by technology. There are at least three challenges associated with this aspect of the content. First, considerable confusion persists, and will almost certainly continue to persist, about the meaning of the term, technology. The vast majority of Americans think of technology as having something to do with computers. Simply, technology is how we as humans change our natural world. The evening news reports on the technology (computer-related) stocks. Politicians strike a positive chord when they promote the increased use of technology in the schools. Curriculum materials need to be designed that increase the awareness of the complexity of the term to include artifacts (things), processes (ways of doing), and technological knowledge. Students need to think about technology as tools, as a mechanism for extending human capability, and about how technology is distinct from the study of science and the study of the natural world. So, an initial curricular challenge is to conceive of ways to expand students' awareness of the complexity of what is meant by technology.

A second challenge follows directly from the first. As with many other content areas, it is one thing to reflect and think about the complexities of technology within the walls of the university. It is quite another to configure university level curriculum in ways that will enable future teachers to engage K-12 students in thinking about technology in engaging and developmentally appropriate ways.

A third challenge has to do with program and curriculum marketing. The release of *Standards for Technological Literacy* certainly will not lead to automatic and immediate acceptance in the school curriculum. The schedule is already full. Future teachers must know that it is one thing to possess basic understanding of the nature of technology. It is quite another matter to be able to communicate these understandings in clear and compelling ways to educational decision-makers. It is essential that university level curricula be developed to cause students to wrestle with these issues in depth and to learn and practice techniques needed to quickly and effectively capture the imagination of a variety of audiences (e.g., students, other teachers, administrators, and parents). Technology education teachers must market the study of technology for all Americans.

One unique and interesting aspect of The Nature of Technology that has been embedded in *Standards for Technological Literacy* has to do with "core concepts" of technology (Standard 2). The framers of the standards attempted to address the question, "What are the core concepts that collectively make technology distinct from other areas of study?" As conceptualized in this standard, these include systems, resources, requirements, optimization and trade-offs, processes, and controls. While other elements could be (and have been) identified, this section presents an interesting and potentially useful conceptual framework for curriculum and program developers. It also represents a substantial departure from the structures used historically to frame curriculum in technology education, which among others have included materials (woods, metals, plastics, etc.), systems (transportation, manufacturing, production, communication, etc.), processes (printing, welding, finishing, etc.), and more. A key issue here is how to incorporate and infuse these core elements into the curriculum. Can they be used as major organizers or do they more appropriately serve the curriculum as persistent threads of emphasis within other curriculum organizational structures? These questions remain to be addressed. But the challenge remains to consider these core concepts seriously as essential to the study of technology.

Technology and Society

Another aspect contributing to a fundamental understanding of technology has to do with its interaction with social and cultural structures identified in the four standards classified as Technology and Society. Since technology is fundamentally a human activity, students must reflect about the ways in which the two, technology and society, interact and exert influence on one another. In some respects, this emphasis on Technology and Society is not new to the technology education curriculum. *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) used the term "human adaptive systems" and many university level technology education programs have been offering courses in technology and society on a campus-wide, general education basis.

What is new in *Standards for Technological Literacy* is an emphasis on the bi-directional nature of the interaction between technology and society. The technology education profession has had much to say about the "impact of technology" on society. This is appropriate and true, but it is simplistic and ignores the complexities of the relationship. Technology has affected virtually every aspect of culture and social institutions in powerful ways including patterns and modes of travel, mechanisms used to communicate with others around the world, forensic analysis of crime scenes, altering natural biological processes, and much more. Society and culture have been fundamentally and profoundly changed by the dramatic and pervasive growth of technology. *Standards for Technological Literacy* quite appropriately acknowledges and elaborates on this important point.

But *Standards for Technological Literacy* also contributes another important understanding to this discussion. Not only does technology impact and influence society, the reverse is also true. Cultural values and social institutions have a powerful shaping influence on technology. Technologies are selected, shaped, marketed, and used, not because they are inherently valuable or even needed. Rather, technology is shaped by powerful cultural and social influences, including factors such as status, competition, efficiency, comfort, and much more.

Technology teacher educators need to understand and help their students understand that this is more than just an interesting academic nuance. Rather, it moves students beyond a simplistic and deterministic view of the role that technology plays in society by causing them to think in more sophisticated ways about the complex, two-way interactions among multiple technologies and complex social systems. Engineering, at its best, is much more involved than designing efficient, functional devices that will somehow impact society, hopefully in positive ways. Rather, most engineering activity is embedded within a rich social context that contains a complex mix of social, cultural, political, and economic constraints, which collectively interact to force engineers to make tradeoffs and compromises.

Technologically literate citizens are aware of how technology influences their lives and communities, both in positive and negative ways. Conversely, they are also equipped and empowered to participate in the process of selecting and shaping the technologies that ultimately gain acceptance and help to decide what will be rejected. Technologically literate citizens are full, participating partners and decision makers, capable of reflecting intelligently about decisions that affect their communities, others, and the environment. To simply observe that technology "impacts" society is to relegate its citizenry to a helpless and passive position. When viewed as a complex interaction among technological and social systems, citizens become active and engaged participants and decision-makers. This is technological literacy and is as it should be in a participative democracy.

Problem Solving, Design, and Technology

The three design standards in Chapter 5 of *Standards for Technological Literacy* identify the elements and essences of design and problem solving. The technology education profession has a rich history of activity-based and applied learning. At best, laboratory activities have involved complex problem solving and sophisticated procedures. At times, technology activities have involved rather low level, uncritical repetition of demonstrated procedures. "Do it this way because it's the best way." Further, some activities have been developed to enhance and reinforce clearly established education goals and objectives. Unfortunately, many technology education activities are selected primarily because they are fun and engaging, instead of their inherent educational value.

If taken seriously, *Standards for Technological Literacy* will challenge and enable teacher educators to develop action-based curricula that clearly are designed to facilitate student learning and enhance technological literacy. This will not be an easy task. As noted earlier, *Standards for Technological Literacy* is designed to clarify the content base of technology, which means that the emphasis will, to some extent, shift away from doing and activities and move toward knowing, reflecting, and thinking. A significant challenge for curriculum developers will be to find ways to facilitate student learning of concepts in active and engaging ways.

Another challenge for teacher educators will be to understand the multidimensional nature of technological problem solving. While *Standards for Technological Literacy* places considerable emphasis on design, a careful reading will reveal that range of technological activity is actually much broader. This is an important point. *Standards for Technological Literacy* presents design and problem solving as a continuum of related, but different processes, which are accomplished in a variety of ways. *Standards for Technological Literacy* resists the tendency to reduce design and problem solving to a series of generic steps that can be applied universally to all situations. They instead realize that different situations and problems may trigger a variety of different strategies and approaches, depending on factors such as expertise, knowledge base, and preferred problem-solving style. In short, most problems can be and are solved in a variety of different ways. One important implication of this for technology teacher education, beyond accounting for the complexity of technological activity, has to do with research. Much remains to be learned about how a variety of factors influence how students learn how to solve a variety of technological problems. This represents fertile ground for research in technology education.

The discussion will now turn to a description of the broad framework used in the standards for understanding technological problem solving and design. As stated in *Standards for Technological Literacy* (ITEA, 2000), "…problem-solving is basic to technology. Design is one type of problem solving, but not all technological problems are design problems. Technology includes many other types of problems and different approaches to solving them…" (p. 90). This is an important point, for more than conceptual reasons. The purpose of technology education and technological literacy extends well beyond teaching students how to be good designers. Rather, engagement with a variety of design and problem-solving situations provides a rich context for learning and can trigger a variety of positive outcomes including learning transfer, critical thinking, active inquiry, and more.

Technological problem solving is a broad category that contains many different types of activity. Students also need to know that not all problems are technological problems. Some problems are social, for example, when two individuals are embroiled in conflict. Other problems may be political, economic, or psychological. As important as these problems are, the focus of technology educators is primarily on solving problems that are technological.

Technology teacher education programs should attempt to configure curricula to engage students across the entire spectrum of technological problems. These include primarily design, troubleshooting, research and development, invention and innovation, and experimentation in problem solving (ITEA, 2000, p. 106). Design involves goal directed activity within a set of constraints. The design process is inherently open-ended, with often, endless solution possibilities as various individuals and teams approach the design task in different ways. Often, design solutions reflect the knowledge base and interests of individual designers. Also, counter to what is sometimes taught, there is no single, generic design process that works in all situations.

Troubleshooting is a distinctly different form of technological problem solving. Whereas multiple solutions are possible with design problems, troubleshooting situations typically concentrate on identifying and isolating a single fault in a system. Also, successful troubleshooting will not occur in the absence of specific technical knowledge. More complex technological systems require increasingly more specialized knowledge. For example, specialized knowledge is required to diagnose and repair a malfunctioning computer network. Good troubleshooting typically involves a systematic and deliberate set of procedures designed to test and to isolate a specific fault. Usually, this involves a set of experiments where a variety of tests are applied on various systems configurations. Research and development involves a wide range of activities designed to move products from design concepts to the market. Most initial designs represent "proofs of concept," where the primary focus is on a design's functionality. Will it work? Research and development addresses a set of larger and typically more complex issues including those that are both technical (how can design be best refined and optimized?) and social (is there sufficient demand for a product or service of this type?). Research and development efforts often engage collaborative teams of engineers, technicians, designers, and scientists.

Invention involves developing creative new technological solutions to address a wide range of needs or possibilities. Typically, invention is a creative enterprise where individuals "think outside of the box" to transform abstract ideas into new objects, devices, or systems. Thought processes are typically divergent, where knowledge is drawn from diverse fields in ways that are often ingenious and sometimes surprising.

Innovation is another key element of technological problem solving. In many cases, innovation represents a "mindset" or corporate philosophy rather than an isolated activity or step in a process. For example, the 3M Corporation, as part of its corporate culture, promotes and awards innovation. Employees are encouraged to come up with new ideas for products as well as new applications for existing products. Innovation involves "thinking outside of the box." Many industries and companies have found that innovation can be stimulated when it is rewarded as part of the corporate culture and teams of employees from diverse departments and varied backgrounds are encouraged to collaborate on finding new solutions to difficult problems.

Experimentation is a form of technological problem solving that is closely associated with science and the scientific method. It is important to note that experimentation is not the same thing as trial and error. Trial and error tends to involve uninformed and even random activity, where the hope is that something will eventually work – that a workable solution will emerge. In contrast, experimentation is much more deliberate and intentional. At its best, it is much more closely associated with the systematic procedures of the scientific method, where steps are planned and tested based on data and experience. Given the need for data and expertise, experimentation is typically conducted collaboratively with scientists, engineers, and technicians.

Procedural development ranges from implementing procedures and plans that have been developed by others to developing the procedures based on knowledge of technological processes. Examples of the first type include assembling a bicycle, exercise machine, or sound system following a set of directions that was included with the packaging materials. An illustration of the second is when an individual uses experience and knowledge of procedures to develop a process plan (step-by-step) from a set of drawings. Similar to the design process, procedural development often involves multiple possibilities.

In sum, the challenge of *Standards for Technological Literacy* is to develop curricula that encompass the breadth of technological problem solving experiences. One serious danger is that technology education programs will concentrate on only one or two forms of technological problem solving to the exclusion of a broader range of experiences and activities. Given the prominence of design in *Standards for Technological Literacy*, the tendency may exist to focus exclusively on design. As important as design is to technology, the focus is unnecessarily restrictive.

Another tendency that should be resisted is the impulse to reduce various types of technological problem solving and design to simplistic formulas or steps. Real problems are typically quite complex and draw on a range of knowledge from a variety of disciplines. Different people and groups solve many of these problems in different ways. As the profession develops the curriculum needed to implement the standards, it is important that pre-service students be engaged in a rich variety of authentic, creative, and integrative experiences. As with other components of the curriculum, this must be done in ways that are developmentally appropriate and within the reasonable grasp of students' ability. This said, it is important that the profession resist the tendency to oversimplify complex technological activities.

FUNDAMENTAL PROCESSES FOR THE STUDY OF TECHNOLOGY

There are two major types of standards in *Standards for Technological Literacy*: What students should know and understand about technology, and What they should be able to do. The first ten standards could be termed as "cognitive" standards. The second ten standards could be classified as "process" standards, which describes the abilities they should have. The process standards are classified as Abilities for a Technological World and The Designed World.

Abilities for a Technological World

Humans must balance their daily activities in three distinct worlds. Surrounding all inhabitants of the globe is the <u>natural world</u> with its laws and principles that are described by science. People interact with other people through their <u>social world</u> with its cultures, mores, political and legal systems, religions and beliefs, and economic activities. Finally, humans have created the designed world with its technological systems and artificial environments to enable them to adapt to and partially control the natural world.

A comprehensive knowledge of technological actions and activities is essential for an understanding of the designed world. This requires individuals to know how people develop, produce, use, and assess technological products, systems, and environments in a number of different contexts.

Design Abilities

The designed world is a product of human creativity and volition. There are numerous ways that the products and structures that make up the designed or human-built world come into being. These activities are often described using terms such as troubleshooting, research and development, innovation, invention, experimentation, and engineering. All of these techniques involve creativity, problem solving, critical thinking, and decision-making. Commonly these approaches are grouped under a term called design, which should be a fundamental focus for any contemporary technology teacher education program. In these programs, students should engage in activities that develop both the knowledge of design and the ability to design artifacts and systems. The students should be prepared to describe and apply the principles of design to a technological problem or opportunity that has appropriate requirements and constraints. This would involve conducting research into consumer and technical issues related to the problem, using divergent thinking to identify or create numerous solutions that solve the problem, using convergent thinking to select an appropriate solution, communicating the solution through appropriate graphic and verbal techniques, and constructing, testing, and evaluating the solution.

Producing Abilities

Designs become useful to people only when they are used to make the things we need or want. A design for a more fuel-efficient automobile is of little value until the design is materialized through production activities. Technology teacher education students should have experiences that allow them to develop fundamental understandings of and abilities to use tools, materials, and technical means to transform materials into products, structures, and environments. They also need to have experiences with organizing, communicating, and storing data, information, and ideas as well as with converting and applying various forms of energy to do appropriate tasks, growing and processing food crops and animals, moving people and cargo, and improving the health and well-being of people.

Using Abilities

Humans use technological products and systems daily and, in many cases, without much thought or understanding. However, a technologically literate person should be able to select, use, and manage appropriate technological products and systems. Therefore, technology teacher education students should develop the ability to identify a range of products and systems that will fulfill needs, select appropriate products or systems for various applications, properly and safely use technological devices and systems, diagnose operational malfunctions, and identify maintenance that is required to restore the product or system to its intended use.

Assessing Abilities

People have serious differences of opinion on the appropriateness of various technologies. A cursory review of any major newspaper will highlight these differences. Technology education students should learn how to assess technology on its merits including, identifying intended and unintended outcomes, and measuring negative and positive impacts, suggesting courses of action to emphasize the intended positive impacts while reducing negative impacts on people and the environment.

The Designed World

Technology is as old as humankind. Its development is one important aspect that differentiates humans from other living beings. Early technology was crude and limited in scope while today's technology is extremely complex and varied. Technology teacher education students should be able to understand how technology is developed, produced, and used in various technological contexts. One list of contexts appears in *Standards for Technological Literacy* (ITEA, 2000, p. 139). It is important to note that this list was intended to represent current and major arenas of technological activity. Given the rapid pace of technological change, other contexts will emerge over time. Given this, the standards document suggests that it is easier to study and understand technology using a classification system that divides the technology into smaller parts or contexts of activity. The activity contexts listed in the document are medical, agricultural and related biotechnologies, energy and power, information and communication, transportation, manufacturing, and construction technologies. The importance of such a list of contexts for technology teacher education students is that they need to understand how technology is embedded in a variety of contexts as they study how technological products and systems are developed, produced, used, and assessed.

TEACHING TECHNOLOGY

Being an effective technology teacher requires more than knowing technological information and possessing certain capabilities. Technology teachers must be able to teach others about technology.

Developing and Using a Philosophy

Early in the educational experience, technology teacher education students should develop a contemporary philosophy that is built upon an understanding of the role of schools in meeting the needs of students and the needs of society. They should understand the challenges involved with balancing the needs of society and the need of individuals in a democratic society. This philosophy should focus on developing technological literacy in all students at all grade levels. The philosophy should also help students articulate the social, cultural, and economic benefits for studying technology.

They should use this philosophy to develop educational goals for technology education programs and individual courses. These goals should focus on helping students learn to understand, use, and manage technological products, systems, and environments.

Determining Program and Course Content

In addition to developing a sound philosophy and appropriate educational goals, technology teacher education students should develop the ability to identify the body of knowledge called technology. This body of knowledge includes events and people that have contributed to the formation of the discipline (e.g., inventions and leaders), techniques that are used to develop new knowledge and practices within the discipline (e.g., design process, invention, and innovation), communication avenues unique to the discipline (e.g., technical vocabulary and technical drawing), and processes used by people in the discipline (e.g., material processes, communication processes, and energy conversion processes).

Students also need to learn how to use their philosophies and goals to select appropriate program and course content from the body of knowledge. This content should define the scope of the course and be sequenced so that students can see logic in the way it is presented. In essence, this is what *Standards for Technological Literacy* was intended to define and clarify.

Developing and Presenting Courses

The essence of the teacher education program is to prepare teachers to present technology to students in an interesting and exciting way. To do this, technology teacher education students must learn how to use numerous teaching methods and strategies. These strategies should range from content-centered to process-centered, individual to group activities, and teacher-led to student-directed experiences.

Assessing Achievement

Finally, technology teacher education students should be challenged with experiences that prepare them to assess at least three different factors. They should be able to assess program adequacies using approved local, state, and national standards. They should also be able to identify strengths of these programs and develop remedial methods to address deficiencies and gauge teacher effectiveness using self, peer, and student evaluation. Third, they should assess student progress using performance measures, examinations, and portfolios.

TECHNOLOGY TEACHER EDUCATION MODELS

No single model can be developed for a technology teacher education program. Since there is considerable diversity among the states and countries and even teacher education institutions within a state, this chapter will present two representative models. One model will be for a technology teacher education program, which is a "stand-alone" program where the majority of the technology education technological, technical, and pedagogical courses are delivered by technology education faculty. The other is an "imbedded" program in which the majority of the technical content is delivered by industrial technology or engineering faculty with the technological and pedagogical instruction controlled by technology education faculty members.

Regardless of the type of program, most university teacher education programs contain four components. First, there is a general education component that is required of all students in the university or the college of education regardless of the subject matter specialty the student is pursuing. Generally, this component has a strong liberal arts focus. Second, there is a general pedagogical component that is required of all students in the college of education regardless of the major being pursued. Third, the subject-specific pedagogical component addresses the teaching concerns and abilities unique for a specific major. Finally, there is the department technical component that addresses the knowledge and skills needed to teach a specific subject in elementary and secondary schools.

This discussion will address the components that are generally under the control of the faculty that delivers technology teacher education; namely, the unique pedagogical and technical content needed by the technology teacher education student.

Stand-Alone Program Model

The stand-alone program allows the university to deliver courses that are focused directly on developing the knowledge and abilities needed to be an effective technology teacher. The students in the program take courses designed to develop broad understanding and general proficiencies needed by technology teachers rather than completing in-depth technical courses from other majors that tend to develop narrower understandings and more specific skills. The representative course titles and descriptions for one example of a stand-alone program are teaching technology courses, design courses, producing courses, using and assessing courses, and capstone courses.

Teaching Technology Courses

Introduction to Technology. Presents an overview of technology and how it interacts with individuals, society, and the environment.

Exploring Technology Education. Introduces teaching technology in elementary and secondary schools.

Teaching Technology. Studies the development and implementation strategies for teaching technology education.

Curriculum Development and Implementation. Studies the design and evaluation of technology-based curriculum and instruction.

Design Courses

Design Techniques. Introduces techniques for developing and communicating technological designs with experiences in sketching, rendering, mechanical and computer-aided drawing, modeling, and presentation skills.

Product Design. Explores a variety of design models and techniques with a focus on elements and principles of design; design processes; and developing, evaluating, modeling, and presenting solutions.

Designing Technological Systems. Explores the design of technological systems and their interrelationship with individuals, society, and the environment.

Producing Courses

Processing Techniques. Presents the tools and machines used for materials, energy, and information processing.

Medical Technology. Studies how medical technology has improved and extended human life.

Agricultural and Medical Technology. Studies how technology is used to improve life through agriculture, biotechnology, and medical applications.

Communication and Information Technology. Studies communication and data processing techniques and systems with emphasis on electronic and graphic media and computer systems.

Construction Technology. Studies construction systems, materials, and processes as they apply to producing buildings and structures.

Energy and Power Technology. Studies how energy is converted and applied to do work.

Manufacturing Technology. Studies technological systems that are used to produce products.

Transportation Technology. Studies technology as it is applied to vehicular and support systems for moving people and cargo in various environments.

Using and Assessing Course

Using and Assessing Technology. Explores the appropriate use and assessment of technology.

Capstone Courses

Technological Enterprise. Presents the relationship between technology and the corporate sector with emphasis on the organization, management, operation, and impacts of a technological enterprise.

Capstone Experience in Technology. A technological product, process, or system is studied through an in-depth research on an approved topic related to technology.

Stand-Alone Program Model Variations

In addition to the typical stand-alone program model (described above), emerging trends in education and the thrust of *Standards for Technological Literacy* suggests two possible variations. These are (a) an integrated, multidisciplinary model and (b) a core concept model.

(a) **Integrated, Multidisciplinary Model.** One important aspect of education reform has focused on the desirability and importance of multidisciplinary connections, integrated content, and learning transfer. As a result, related disciplines (particularly science and mathematics) have included technology components in their content standards and are actively pursuing collaborative opportunities with technology education. Indicators of this interest include the active support of technology education in recent years such as involvement with organizations such as the National Science Foundation and the National Academy of Sciences and Engineering.

An innovative integrated, multidisciplinary model could be developed where large blocks of time could be dedicated to integrated modules, team taught by faculty from different disciplines (e.g., technology and science education faculty). These courses could focus on such topics as the shared content between disciplines, the challenges associated with promoting interdisciplinary teaching in the public schools, shared activity ideas, etc. These integrated modules could serve as "plug-ins" in lieu of (or in addition to) more typical stand alone model courses or topics (i.e., construction, design, etc.). These could be conducted on a seminar or short course basis, which would facilitate flexibility. Alternatively, these courses could be processed through the formal curriculum process and become regularly offered and required by participating departments.

While the development of this type collaborative model usually presents difficult challenges for academic administrators and faculty, the thrust of multiple sets of standards and the demand for and interest in cross-disciplinary collaboration suggest interesting and exciting possibilities.

(b) Core Concept Model. A second variation on the stand-alone model focuses on core concepts. One of the historical problems that have confronted technology education has been a tendency to emphasize activities and processes over content and conceptual development. The development of the *Standards on Technological Literacy* represents a major step forward by shifting the emphasis toward what it is that students should be learning through activity-rich technology classes.

Similar to the multidisciplinary "plug-in" model described above, a course could be designed to explore core technological concepts in depth. This would focus on the concepts identified in *Standard* 2 of *Standards for Technological Literacy* (i.e., optimization, trade-offs, systems, etc.), but it could also be expanded to focus on topics such as outcomes, technological assessment, technology transfer, etc. Again, as with the integrated, multidisciplinary model variation, this core concept model represents an alternative conceptual framework for program and curriculum development.

Imbedded Program Model

The primary difference between the stand-alone and imbedded program models for technology teacher education has to do with the method used to deliver technical content and experiences. The general education and pedagogical components of the two program models are typically very similar. The discussion in this section will concentrate on the technical component of the program.

In many universities around the United States, technology teacher education is housed in departments of industrial or engineering technology where a comprehensive range of technical and managerial courses are being delivered by industrial or engineering technology faculty to non-teaching and teaching majors. Within these programs, typical concentrations include manufacturing, electronics, computer-aided drawing/design, printing, graphic design, construction management, computer network systems, telecommunication systems, industrial safety and maintenance, aviation technology, and automotive systems.

The primary rationale for delivering technical courses in these programs is to provide students with a general base of experience and knowledge with the types of equipment and processes that are used by technicians. In many cases, the equipment is similar to that used in industry and the focus is on preparing technically-oriented managerial professionals. These arrangements pose some difficulty for technology education students, who need to be prepared to use smaller table-top equipment, modules, and other more generally applicable tools and equipment. Among the significant challenges for technology teacher education faculty in institutions using the imbedded model is to assist students in thinking through how to appropriately translate their learning obtained in industrially-based laboratories into the kinds of laboratories and classrooms that they will encounter in the public schools. The old adage that "we teach how we were taught" still applies. It is important that university technology teacher education faculty discuss these distinctions rather than assuming that students will be able to figure it out when they enter their public school classrooms and laboratories.

With regard to content, technology teacher education students in imbedded programs typically enroll in the same courses as their fellow industrial or engineering technology students. In most cases, however, teacher education programs specify a broad selection of courses spanning a range of technological systems (e.g., transportation, production, construction, communication). This is in contrast to industrial and engineering technology programs where technical courses are categorized in a particular industrial area (e.g., electronics, printing, computer-aided manufacturing, construction management). Conceptually, the difference is that teacher education programs are designed to focus on general technological literacy for all students (breadth), whereas industry-based programs concentrate on preparing students for middle management roles in industry (depth).

Consistent with the comments previously made about laboratory differences, it is important that university technology teacher education faculty assist students with connecting and "translating" technical content into activities and curricula that are appropriate for technology education at the K-12 level. This must be an intentional process for the faculty. Since many teachers teach the way they have been taught, technology teacher educators must show students how to take highly technical content, such as that learned in university industrial technology laboratories, and translate it into curriculum and activities appropriated for K-12 technology education classes.

Strategies for helping students grapple with the differences between technical experiences obtained in industry-based courses and what they must be prepared to deliver in K-12 classrooms include:

- Have teacher education assignments in technical courses as alternatives to those focused on industrial applications (i.e., developing a unit of instruction or a lesson plan).
- Engage teacher education students in focused discussion of how to translate their laboratory experiences into their classrooms. Most teacher education programs using the imbedded model conduct this type of discussion as part of advanced level teaching methods courses.
- Form ties between technical courses and methods courses.
- Constantly work with technical course faculty, encouraging them to provide teaching major alternatives and opportunities.
- Encourage students to utilize electronic portfolios or other techniques to keep a catalog of technical experiences for use in the classroom.

SUMMARY

Standards for Technological Literacy represents a significant opportunity and challenge for the technology education field. This is particularly true for technology teacher educators, who are charged with the critically important task of reconceptualizing pre- and in-service education to align with *Standards for Technological Literacy*. Taken seriously, this could represent one of the most significant and demanding challenges to be confronted in the history of technology teacher education.

THOUGHT-PROVOKING ACTIVITIES

1. What components of *Standards for Technological Literacy* are not yet being incorporated into your technology teacher education program? What would you need to change in order to incorporate these components?
2. Given the strong emphasis of design and problem solving in *Standards for Technological Literacy*, what changes are needed in your program to prepare pre-service teachers to teach this content and ability in their classrooms?
3. In the curriculum and program development components of your teacher education program, and in light of *Standards for Technological Literacy*, what suggestions will you make to pre-service teachers about how to structure courses and curriculum? Should curriculum be organized around the Designed World contexts (*Standards* 14–20) or around topics such as design, technology and society (*Standards* 4-7), core concepts (*Standard* 2), etc.?
4. This chapter outlines two models for technology teacher education programs, the Stand-Alone Program Model and the Imbedded Program Model. Which most closely describes your program and what aspects of the alternative model could be incorporated to improve your program?

REFERENCES

American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

International Technology Education Association (ITEA). (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

National Commission on Teaching and America's Future (NCTAF). (September 1996). *What matters most: Teaching for America's future.* New York: Author.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Research Council (NRC). (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington, DC: National Academy Press.

National Research Council (NRC). (1996). *National science education standards.* Washington, DC: National Academy Press.

Snyder, J. & Hales, J. (1981). *Jackson's mill industrial arts curriculum theory.* Charleston: WV, West Virginia Department of Education.

Instructional Strategies

Section VII

STANDARD 7—INSTRUCTIONAL STRATEGIES
Technology teacher education program candidates use a variety of effective teaching practices that enhance and extend learning of technology.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 7. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Base instruction on contemporary teaching strategies that are consistent with Standards for Technological Literacy. • Apply principles of learning and consideration of student diversity to the delivery of instruction. • Compare a variety of instructional strategies to maximize student learning about technology. • Describe a variety of student assessments appropriate for different instructional materials.
Performance Indicators:
• Apply appropriate instructional technology materials, tools, equipment, and processes to enhance student learning about technology instruction. • Assess instructional strategies to improve teaching and learning in the technology classroom by using self-reflection, student learning outcomes, and other assessment techniques.
Disposition Indicators:
• Exhibit an enthusiasm for teaching technology by creating meaningful and challenging technology learning experiences that lead to positive student attitudes toward the study of technology.

Instructional Strategies For Technology Education

Chapter 10

Anthony E. Schwaller (Professor & Chairman)
St. Cloud State University
St. Cloud, Minnesota
44th CTTE Yearbook, 2003

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 1980s and 1990s, 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 fifteen to twenty 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 fifty percent of his/her education preparation to develop content, and another fifty percent 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 maybe 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.

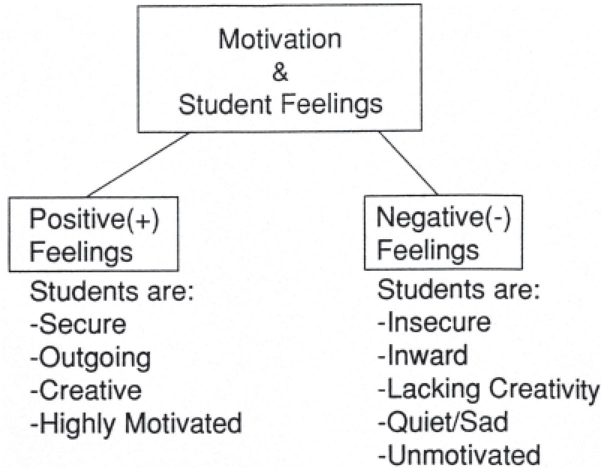

Figure 10–1. Motivation in the classroom is directly related to how a student feels.

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 10-1 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.

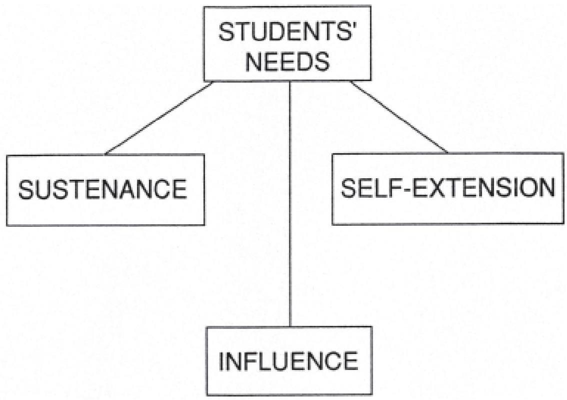

Figure 10–2. Students' needs can be categorized into three types.

Students' needs can be subdivided into three major types: sustenance, influence, and self-extension. These three types of needs are shown in Figure 10-2.

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 10-3 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, 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 workmanship within the psychomotor domain If a student has developed strong and valid attitude 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.

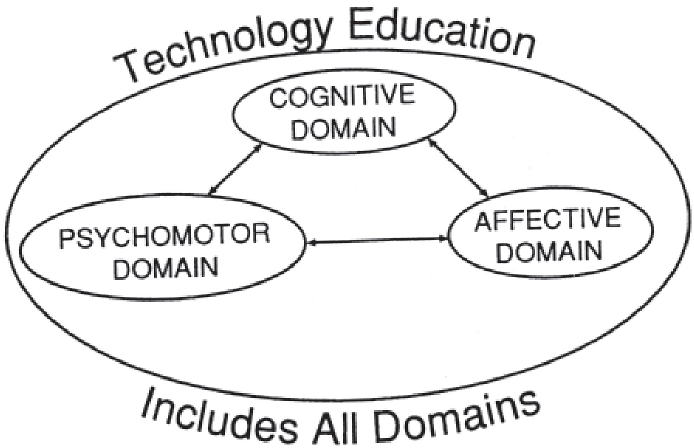

Figure 10–3.The three domains of Bloom's taxonomy.

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 emphasize 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 process 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.

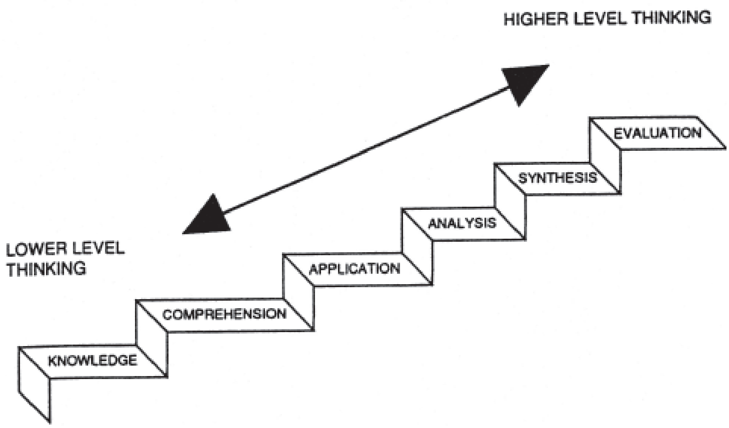

Figure 10–4. The six levels of learning in the cognitive domain.

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 HOTS (Scanlin, 1992), are related to the various sublevels of learning within the cognitive domain. Figure 10-4 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 10-5. Traditional classroom teaching and learning styles tend to concentrated on the lower order thinking skills such as knowledge, comprehension, and application, while technology education challenges teacher 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.

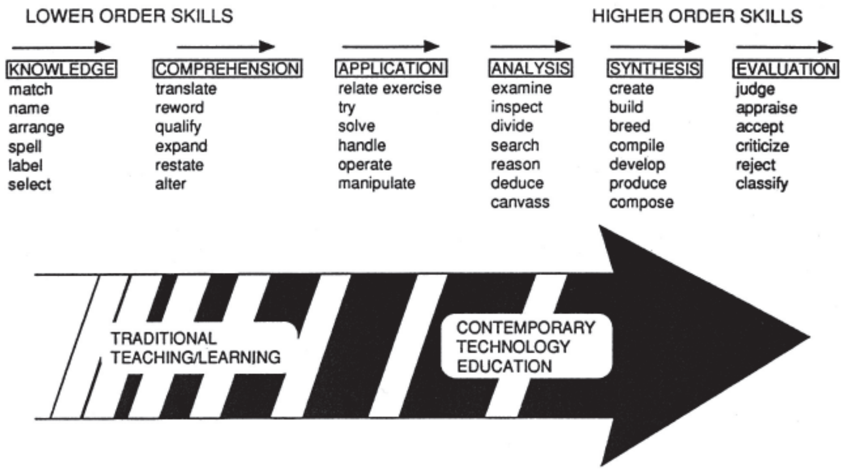

Figure 10–5. Verbs are used to describe each of the six levels in the cognitive domain.

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 makeup 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 10-6 (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 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.

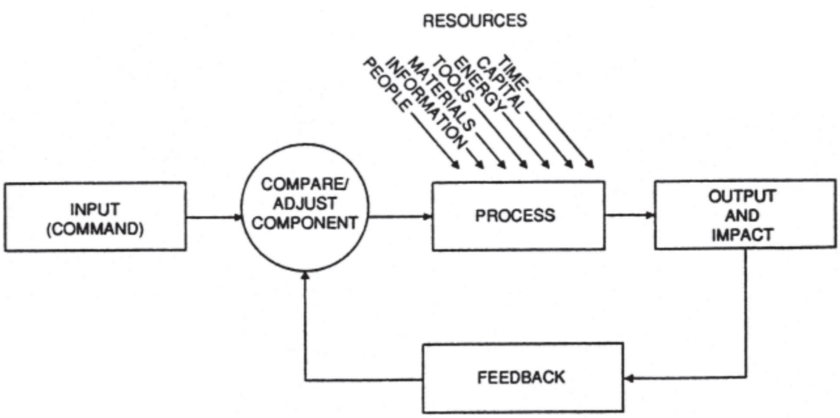

Figure 10-6. All technologies can be studied by using the systems model.

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 impact so each technological area being studied.

There are several advantages to using the social/cultural/environmental approach which includes 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 capacity 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 process (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 teachers 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 place 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 activates. 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 workplace, 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, 1938). 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 thin 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 available 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.

REFERENCES

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of educational objectives. *The classification of educational goals. Handbook I: Cognitive domain* New York: David McKay.

Cochran, L. (1970). *Innovative programs in industrial education*. Bloomington, IL: McKnight.

Daiber, R. A. (1988). Discovery inquiry and experimentation. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 166–182). Mission Hills, CA: Glencoe.

DeVore, P. W. (1980). *Technology: An introduction.* Worcester, MA: Davis.

Edmison, G . A. (1992a). Interdisciplinary teaching in technology education. In G. A. Edmison & A. E. Schwaller (Eds.), *Approaches: Teaching strategies for technology education* (pp. 18-24). Reston, VA: International Technology Education Association.

Edmison, G. A. (1992b). Modeling/gaming/simulation in the technology education classroom. In G. A. Edmison & A. E. Schwaller (Eds.), *Delivery systems: Teaching strategies for technology education* (pp.7–13). Reston, VA: International Technology Education Association.

Gilberti, A. F. (1992). Teaching technology education with a science, technology, and society approach. In G. A. Edmison& A. E. Schwaller (Eds.), *Approaches: Teaching strategies for technology education* (pp. 8–13). Reston, VA: International Technology Education Association.

Henak, R. (1992). Learning in groups. In G. A. Edmison & A. E. Schwaller (Eds.), *Delivery systems: Teaching strategies for technology education* (pp. 24). Reston, VA: International Technology Education Association.

Henak, M. (1988). Cooperative group interaction techniques. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 143-164). Mission Hills, Glencoe.

Johnson, I. H. (1985). Games and simulation. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 183–200). Mission Hills, CA: Glencoe. Kemp, W. H., & Schwaller, A . E. (1938). Instructional strategies for technology education Mission Hills, CA: Glencoe.

Krathwohl, D. R., Bloom, B. S., & Masia, B; B. (1964). *Taxonomy of educational objectives. The classification of educational goals. Handbook II: Affective domain*. New York: David McKay.

Minnesota Department of Education. (1985). *The Minnesota plan for industrial technology education.* St. Paul, MN: Minnesota Department of Education.

Orlich, D. C. (1985). *Teaching strategies: A guide to better instruction.* Lexington, MA: Heath.

Scanlin, D . (1992).Higher order thinking skills in the technology education classroom. In G. A. Edmison & A. E. Schwaller (Eds.), *Approaches: Teaching strategies for technology education* (pp.25–28). Reston, VA: International Technology Education Association.

Schwaller,A . E. (1989). *Transportation, energy and power technology.* Albany, New York: Delmar.

Thomas, J . W. (1981). *Making changes: A futures-oriented course in inventive problem solving.* Palm Springs, CA: ETC Publishers.

Wright J. R. (1983). Social/cultural approach. In W. H. Kemp & A. E. Schwaller. (Eds.), *Instructional strategies for technology education* (pp. 72–86). Mission Hills, CA: Glencoe.

Wright, P. H. (1992).Futuring in the technology education classroom. In G. A. Edmison and A. E. Schwaller (Eds.), *Approaches: Teaching strategies for technology education* (pp. 6-7). Reston, VA: International Technology Education Association.

Yoho, L. (1967). *The orchestrated systems approach to industrial education.* Terre Haute, IN: Indiana State University.

Zuga, K. F. (1988). Interdisciplinary approach. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 56–71). Mission Hills, CA: Glencoe.

Teaching Social/Cultural Impacts in Technology Education

Chapter 11

Brian McAlister
University of Wisconsin—Stout
Menomonie, Wisconsin
52nd CTTE Yearbook, 2003

INTRODUCTION

We are at a defining moment in the history of technology education. The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) have been released with the backing of the International Technology Education Association, the National Aeronautics and Space Association (NASA) and the National Science foundation (NSF). It is important to note that four out of the twenty content standards specifically address technology and society. That is why the content of this chapter is so timely. Now that the foundation has been set, it is time to implement curricular and instructional design changes that reflect the needs of a changing society.

PURPOSE

The purpose of this chapter is to provide information on how social and cultural impacts can be effectively addressed when teaching technology. This chapter will be a valuable resource for classroom teachers when modifying their curriculum to address the content standards that relate to social and cultural impacts. University technology teacher educators will find this chapter useful when preparing future teachers by providing them with instructional strategies that address social and cultural impacts. Graduate students will also find this chapter to be beneficial as a resource whether they are preparing to become master teachers, developing standards-based curriculum, or exploring a professional research agenda.

SOCIAL/CULTURAL IMPACTS

Technology, society, and culture are all common terms. But one only needs to consider the word *technology* to understand that terms often mean different things to different people. Consider the variety of interpretations of the word *technology.* According to an ITEA/Gallup poll on technological literacy (Rose & Dugger, 2002), two-thirds of the American respondents "think only of computers and matters related to the Internet" (p. 1) when they hear the word *technology.* It is no surprise that most technology committees in school districts focus on policies related only to computers. The meanings of words also evolve over time: "As the definition of technology changed, it's meaning became more vague, leaving room for misconceptions" (Pearson & Young, 2002, p. 51). Because of the evolutionary nature of language and since the thrust of this chapter requires an understanding of the relationship among technology, society and culture, it is important to first clarify these terms.

Definition

Technology

A plethora of definitions of technology are cited in the literature. Rather than to rehash that which has already been over-analyzed, the following definition is offered from the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000):

> Broadly speaking, technology is how people modify the natural world to suit their own purposes. From the Greek word *techne,* meaning art or artifice or craft, *technology* literally means the act of making or crafting, but more generally it refers to the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants. (p. 2)

Society

A society is any group of people who freely associate with each other for the purpose of some common goal. Dewey (1915) defined *society* "[as] a number of people held together because they are working along common lines, in a common spirit and with reference to common aims" (p. 14). This definition parallels the *Webster's New Collegiate Dictionary*

(1981) second entry for society: "a voluntary association of individuals for common ends; esp.: an organized group working together or periodically meeting because of common interests, beliefs, or profession" (p. 1094). It is interesting to note that while, by definition, a society must be larger than one person, none of these definitions puts a limitation on the size of the group. A society could include a small social club of two or involve millions of people such as the members of the Incan Empire.

Textbook definitions tend to include additional variables when defining society. Nanda & Warms (1998) in their cultural anthropology text suggest "society is a group of people who depend on one another for survival and well-being" (p. 3). According to this definition, a group organized and structured around family bloodlines such as Scottish clans qualifies as a society. A society could also include Native American tribes whose members share hunting and other survival responsibilities.

Macionis (2001) offers this typical sociology textbook definition: "People who interact in a defined territory and share culture" (p. 89). Historically, geographic location was an important determiner when defining the characteristics of a society, but today, modern transportation and electronic communication technologies have altered the importance of including the concept of a limited territory as part of a defining element of a society. On the other hand, the concept of a shared culture is as important today as it was a thousand years ago.

Culture

Any time a group congregates as a society, members of that group tend to develop their own habits, behaviors and ways of being. *Culture* can be defined as "the integrated pattern of human behavior that includes thought, speech, action, and artifacts and depends upon [humans'] capacity for learning and transmitting knowledge to succeeding generations" (*Webster's New Collegiate Dictionary,* 1981, p. 274). According to Pytlik, Lauda, and Johnson (1985), three common factors pervade definitions given by sociologists and anthropologists. The first common factor is that culture is learned, not inherited genetically. Using this tenet as a guide, language would be considered a cultural phenomenon whereas physical characteristics such as skin pigmentation would not. The second common factor identified by Pytlik, Lauda and Johnson (1985) is that culture is modified as it is passed on from generation to generation. Because the way people communicate continues to evolve over time, language evolves as new slang becomes common and eventually becomes adopted as part of the mainstream. The third common factor that pervades definitions of culture is the way in which humans assign meaning to their lives. This assigning of meaning is often done through the meaningful alteration of their environment. Values and symbolism are given to the materials with which they come in contact and the artifacts that are created, exemplified by the status attributed to the clothing and the meaning some give to how it is worn.

Macionis (2001) defined *culture* as "the values, beliefs, behaviors, and material objects, that together form a way of life" (p. 61). He also made distinctions between nonmaterial and material culture. *Nonmaterial culture* is defined as "the intangible world of ideas created by members of a society, ideas that range from altruism to Zen" (Macionis, 2001, p. 61). *Material culture* is defined as "the tangible things created by members of a society" (Macionis, 2001, p. 61). The ways in which different societies design and create technologies, their material culture, provide insight to their values and beliefs, their nonmaterial culture.

INTERRELATIONSHIPS BETWEEN TECHNOLOGY, SOCIETY AND CULTURE

The world is filled with physical evidence of how humans have altered their environment. Much of what we proclaim to know about past societies is based on the artifacts that archeologists have found. If it were not for the discovery of tools, clothing, and remnants of structures, our understanding of prehistoric cultures would be greatly limited. To understand the technology of a culture is to provide a deeper understanding of the creators of that technology. Ever since the first technologies were invented, a symbiotic relationship was established. Technologies exist because of the ingenuity of humans. And human lives have been altered because of their creations. If technology is changed or altered, then society is generally affected. For this reason, technology must also be studied from a social and cultural viewpoint. If the study of technology is limited to the manipulation of materials or the creation of artifacts, without further attention to understanding the social and cultural contexts which govern its creation and implementation, then the goal of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) will not be met.

One of the defining features of a society is the culture established when a group adopts its own protocols or alters its physical environment.

Rules of thumb evolve, ways of living are propagated, and rituals are established. Societies create technologies that reflect their culture, as well, just as a culture limits the technologies that are created and/or implemented. In addition, groups, regardless of their size, can establish ways of communicating that prohibit outsiders from functioning effectively within the group. When someone is disoriented because of an experience with an unfamiliar way of life, it is called culture shock (Macionis, 2001). Sometimes this disorientation is intentional, while at other times, social change may occur leaving those who are not early adapters to muddle along behind the learning curve. Mesthene (2000) suggested that technology-driven social change could be explained as a four-step process:

> The usual sequence is that (1) technological advance creates a new opportunity to achieve some desired goal; (2) this requires (except in trivial cases) alterations in social organization if advantage is to be taken of the new opportunity, (3) which means that the functions of the existing social structures will be interfered with; (4) with the result that other goals which were served by the older structures are now only inadequately achieved. (p. 63)

An example of this sequence is the invention of the automobile. The automobile provided a new opportunity for travel. In order for the automobile to be successfully adopted, the social structure that governed the transportation infrastructure in our country had to be altered. A need was created for places to purchase fuel and service automobiles. At the same time, the demand for harness makers and other occupations related to transportation systems that relied on animal power diminished. As a result, some of the occupations related to the use of animals for transportation still exist, but clearly not at the level they did a hundred years ago.

One mistake commonly made when examining impacts as they relate to technology, society, and culture is to look only at how technology impinges on society. However, it is equally important to note that the culture of a society often can impact the invention and implementation of technology. Using the automobile once again as an example, one needs to look only as far as the Amish to understand this point. The Amish have an established culture that shuns the invention of the automobile. They know that the technology exists but have refused to make it a part of their everyday lives because of their own values and beliefs.

TEACHING SOCIAL/CULTURAL IMPACTS IN THE TECHNOLOGY EDUCATION CLASSROOM

Teachers can choose various approaches to teaching the relationships among technology, society, and culture. The approaches can be organized along a continuum based on the scale ranging from integrated content to topical lessons, from unit activities to complete courses.

One approach is to integrate technology and society content throughout the existing curriculum. For example, exploring current issues related to regional trends could enhance a manufacturing lesson. Questions could be posed that ask students to explore the impacts a manufacturing facility has on the lives of their local community. How many people are employed in the plant? How many are employed in jobs that provide materials and services for the plant? Similar types of topics could be developed and integrated across the technology curriculum.

Another approach is to develop standalone topical lessons that specifically address technology and society issues. For example, a communications technology lesson could be developed that asks students to explore the concept of privacy in the age of the Internet. Students could contemplate how humans have benefited and have been harmed by a technological system that was created to increase a human's ability to exchange information. Such technology and society related lessons could be added to enhance pre-existing units.

The unit activity is another valuable way to incorporate social and cultural content. The unit could be developed not as an enhancement to a preexisting lesson but as a standalone topic/activity that specifically addresses technology and society content. The unit could include a series of related lessons and activities organized around a central theme. One approach is to have students interview grandparents or senior citizens about what they perceive to be the most influential technology they have encountered in their personal lives. This activity would start with a pre-interview to identify the technology to be investigated. Next, students would research the historical development of the technology selected. They could also either develop a physical model of the technology or simulate its operation. Students could also be asked to develop a list of interview questions based on their research on the history of the technology, along with the development of a video of the interview. The final product could be a multimedia presentation stored on a CD or web page that documents each aspect of the project. It would include links to a research paper about the historical development of the technology, pictures of the technology and the interviewee, a biographical sketch of the interviewee, digital video of a memorable moment from the interview, and a complete transcript of the interview including the questions and responses. Such an activity would provide students with an in-depth understanding of how technology can impact society through the personal experiences of an individual.

The most ambitious approach is to create a separate course dedicated to the coverage of the relationship among technology, society, and culture. Suggested topics might include but definitely would not be limited to the following:

A) Studying interrelationships among technology, society, and culture
  1) Technology and social change
  2) Technology and culture

B) Attempting to assess and control technology
  1) Technological politics
  2) Technology assessment
  3) Cost/benefit analysis
  4) Risk assessment
  5) Futuring

C) Confronting technological issues
  1) Privacy in the age of the Internet
  2) Technology used to create, prolong, and/or end life.
  3) Cloning and genetic engineering
  4) Improved technology and its relationship to progress

D) Noting trends
  1) Nanotechnology
  2) Macrotechnology
  3) Genetic engineering

Creating a class provides students with opportunities to explore the relationship among technology, society, and culture at a very deep, rich level. The state of Wisconsin has recently endorsed a similar type of class at the high school level as an advanced placement course that can be used for university credit. Although a class like this may provide an opportunity for college bound students to earn college-level credits, the content is appropriate for all students.

STRATEGIES FOR TEACHING SOCIAL/ CULTURAL IMPACTS

A Case for Case Studies

One method of incorporating content that addresses the interrelationship among technology, society and culture is to utilize case studies. Case studies have been used very effectively in medical and law schools. Because students have limited experiences, case studies provide an opportunity to investigate real world events that they may not otherwise have experienced. One approach is to investigate historical events. For example, much has already been documented about catastrophes such as the Hindenberg, the Titanic, the Challenger, Three-Mile Island, Chernobyl, and the attack on the World Trade Center in New York City. Pre-existing accounts of these events allow students to investigate how society changed in reaction to such catastrophes. Another approach is to have students write their own case studies. They can do observations and interviews to gather information to document how technology has impacted a person, a group of people, a company or business, or the natural environment. Students could also write personal case studies. They could document how they have impacted or have been impacted by a technological innovation. Another interesting approach is to combine the idea of futuring with the case study approach. Students could write predictive case studies explaining how life might be different for individuals in the future because of technological inventions and innovations. Case studies provide students with a variety of opportunities to investigate the relationships between technology and society.

RELATIONSHIP TO STANDARDS FOR TECHNOLOGICAL LITERACY

Chapter 4 of the *Standards for Technological Literacy: Content for the Study of Technology*. (ITEA, 2000), titled "Technology and Society," outlines four standards, standards 4–7, that relate specifically to the content of this chapter of the yearbook. Because standards represent big ideas, no single approach will be sufficient to address these standards. It is recommended that a combination of approaches be utilized to give students multiple exposures to key ideas and concepts over time in order to meet the rich intent of the standards. These are the Technology and Society Standards:

> Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
>
> Standard 5: Students will develop an understanding of the effects of technology on the environment.
>
> Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
>
> Standard 7: Students will develop an understanding of the influence of technology on history. (ITEA, 2000, p. 210)

ACTIVITIES

Activities that illuminate the relationship among technology, culture, and society can be implemented at all grade levels. The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) include benchmarks at various age levels for each standard. The following are example activities that could be implemented to address selected benchmarks. Each suggested activity starts with the listing of the targeted standard and specific benchmark(s).

Grades K–2 Activity

> Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology. (ITEA, 2000, p. 57)
>
> Benchmark A: The use of tools and machines can be helpful or harmful. (ITEA, 2000, p. 58)

At the early elementary level, students could be asked to bring in pictures of common technological artifacts. They should be encouraged to bring in a variety of examples that cut across human endeavors. As a class they could pick one and describe for what purpose it was created: How did its inventor intend for it to be used? They could also brainstorm other applications of the technology for which it could be used beyond its intended purpose. Asking how that particular technology could be used to help people and how it could be used to harm people could help students understand that technology can be both harmful and helpful.

Grades 3–5 Activity

> Standard 6: Students will develop an understanding of the role of society in the development and use of technology. (ITEA, 2000, p. 73)
>
> Benchmark C. Individual, family, community, and economic concerns may expand or limit the development of technologies. (ITEA, 2000, p. 76)

Elementary aged students can learn much through interactions with other students their age from other parts of the country or world. The idea of using pen-pals to share information is not new, but the ability to do so has been enhanced with the introduction of the Internet. A classroom teacher could establish connections with teachers from other parts of the country or world to help organize a pen pal activity where students are given an opportunity to learn first hand that technology can vary from region to region or country to country. This activity will work best if caution is taken to identify schools from diverse areas. Students from a seaport in Maine, a mining town in West Virginia, a ranching community in Western Kansas, and an urban school in New York City could provide a variety of different responses to the same questions. Students from different countries would provide an even greater variety of responses. Possible questions to be explored could include the following: How do you get to school? How many televisions do you have? Where do your parents work? What kind of house do you live in? Students could also be encouraged to send digital pictures showing examples of local transportation, construction, architecture, communication systems etc. A pen-pal activity such as this could help students understand that technology can be similar but can also vary from family to family, community to community, state to state, and country to country.

Grades 6–8 Activity

> Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology. (ITEA, 2000, p. 57)
>
> Benchmark C: The use of technology can have unintended consequences. (ITEA, 2000, p. 59)
>
> Benchmark D: The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use. (ITEA, 2000, p. 60)
>
> Benchmark E: Technology, by itself is neither good nor bad, but decisions about the use of products or systems can result in desirable or undesirable consequences. (ITEA, 2000, p. 60)

An appropriate middle school activity that would help meet these benchmarks could involve the exploration of the impacts of an existing technology. One method to explore possible impacts is to have students create a web diagram placing the technology to be investigated in the middle. Simple technologies like a paper clip often work as well as complex technologies. Next, have the students list the primary impacts of the technology in circles surrounding the technology with lines linking them back to it. See Figure 11-1. Impacts of Technology. Then, students should list the secondary impacts with lines linking them back to the related primary impacts of the technology. Lastly, have students list tertiary, or third-level impacts, making connections back to the related secondary impacts. Once students have explored levels of impacts, they should be asked to categorize each impact into the following categories: intended/desirable, unintended/desirable, intended/undesirable, unintended/undesirable. Students could explore impacts of the same technology individually, and the instructor could instruct them to compare their results with each other using cooperative learning techniques.

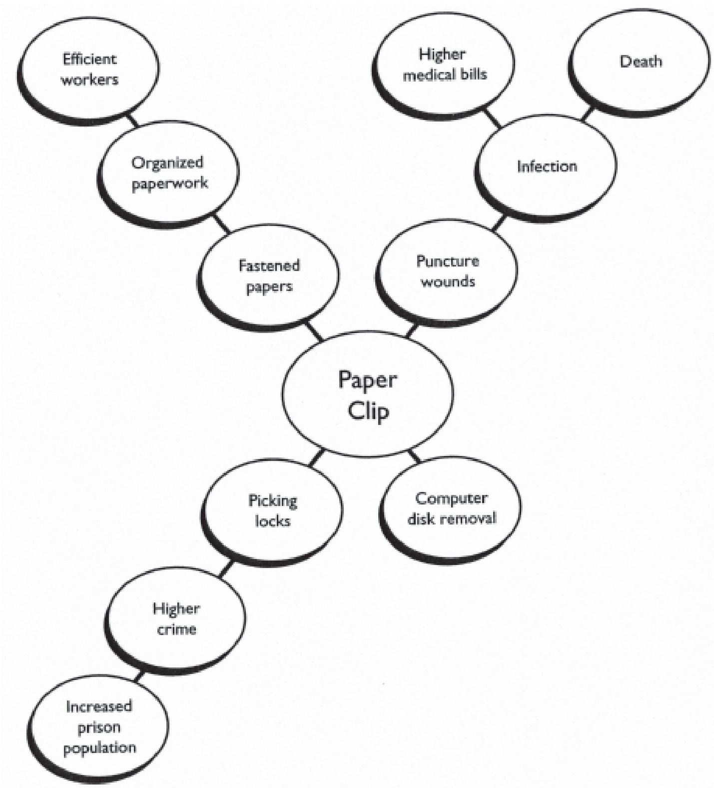

Figure 11-1: Impacts of Technology.

Grades 9–12 Activity

Standard 5: Students will develop an understanding of the effects of technology on the environment. (ITEA, 2000, p. 65)

Benchmark H: When new technologies are developed to reduce the use of resources, considerations of tradeoffs are important. (ITEA, 2000, p. 71)

Benchmark J: the alignment of technological processes with natural process maximizes performance and reduces negative impacts on the environment. (ITEA, 2000, p. 72)

Benchmark K: Human devise technologies to reduce the negative consequences of other technologies. (ITEA, 2000, p. 72)

> Benchmark L: Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment. (ITEA, 2000, p. 72)

Many technology education programs have incorporated design and problem-solving activities. Researching possible positive and negative impacts of a design solution can easily become a standard part of any evaluation criteria that is used when selecting the optimum solution. The perfect place to begin is to require that social cultural impacts be incorporated into design specifications. Design specifications should not only include desirable functional qualities but also should focus on impacts on the environment and society. Typical criteria could focus around questions such as these: What percent of the materials used in the design solution can be recycled? Does the design solution require electricity? Does the design solution require materials that require an exorbitant amount of primary processing that has adverse consequences for the environment? Students could also be asked to determine whether any social/cultural barriers might inhibit the implementation of their design solution including a list of possible policies or regulations that would need to be developed if the new technology were to be successfully implemented. Asking students to incorporate these types of questions in their analysis of possible solutions will help them understand that selecting optimal design solutions involves tradeoffs.

SUMMARY

Technology education has evolved with a rich tradition. It is interesting to note that many prominent philosophers in education have called for better linkages between schools and society. Dewey (1915) started calling for the reformation of schools to better reflect the social changes that were occurring in the United States approximately one hundred years ago. Leaders in our field, such as Don Maley, introduced curriculum that included technology and society content fifty years ago. Now, with the publication of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) to guide the content for the study of technology, we have some clear goals for technology education across the nation. Humans continue to mold and shape their worlds through the use of technology, and in turn technology has changed many lives. It is only fitting that students gain a better understanding of interrelationships between the human altered world and the cultures and societies that molded them. In what better place should this occur than in our schools as a part of every child's formal education.

DISCUSSION QUESTIONS

1. Why is it important for technology education teacher at all levels to incorporate the social and cultural impacts of technology?
2. What are the differences between the words *society* and *culture* when speaking of technology?
3. What is the difference between material and nonmaterial culture?
4. Can you provide an example of the four step process Mesthene used to describe technology-driven social change?
5. Can you develop a case study of how technology, society and culture interrelate so that it can be studied by your students?
6. Can you develop an outline for a complete course of study that shows the integration of technology, society, and culture?

REFERENCES

Dewey, J (1915). *The school and society.* (Rev. ed.). Chicago: The University of Chicago Press.

International Technology Education Association. (2000). *Standards for technological literacy: Content for the study of technology*. Reston, VA: Author.

Macionis, J. J. (2001). *Sociology.* (8th edition). Upper Saddle River, NJ: Prentice Hall

Mesthene, E. G. (2000) The role of technology in society. In A. H. Teich (Ed.), *Technology and the future* (8th edition, pp. 61–70). New York: Bedford/St. Martins.

Nanda, S. & Warms, R. (1998). *Cultural anthropology.* (6th edition) Belmont, CA: West/Wadsworth.

Pearson, G. & Young, A.(Eds.). (2002). *Technically speaking* (Rev. ed.). Washington D.C: National Academy Press.

Pytlik, E. C., Lauda, D. p. & Johnson, D. J. (1985). *Technology, change and society.* (Rev. ed.). Albany, NY: Delmar Publishers, Inc.

Rose, L.C. & Dugger, W. E. (2002). *ITEA/Gallup poll reveals what Americans think about technology.* Reston, Va: International Technology Education Association.

Webster's new collegiate dictionary. (1981). Springfield, MA: G&C Merriam Company.

Learning Environments

Section VIII

STANDARD 8—LEARNING ENVIRONMENTS
Technology teacher education program candidates design, create, and manage learning environments that promote technological literacy.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 8. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Recognize rich learning environments that provide for varied educational experiences in the technology classroom and laboratory. • Identify learning environments that encourage, motivate, and support student learning, innovation, design, and risk taking.
Performance Indicators:
• Design learning environments that establish student behavioral expectations that support an effective teaching and learning environment. • Create flexible learning environments that are adaptable for the future.
Disposition Indicators:
• Exhibit safe technology laboratory practice by designing, managing, and maintaining physically safe technology learning environments.

Environmental and Climate Challenges in Technology Education

Chapter

12

Jane A. Liedtke
Illinois State University
47th CTTE Yearbook, 1998

> In the world that is coming, if you can't navigate differences, you've had it.
>
> (Robert Hughes, 1992)

"Progress through the pipeline hasn't been good for women and minorities in the last 12 years. Presidents Reagan and Bush put affirmative action on the back burner, signaling that it wasn't important" contended Galagan (1995b, p. 50). Some government estimates indicate that minorities will make up nearly half of the U.S. population by 2050. Dovidio (1995) reported that in the workplace "racial issues are already receiving serious attention, with companies striving for greater awareness and deeper understanding" (p.51).

Today, women, people of color and immigrants hold more than half the jobs in the United States. But the elimination of thousands of middle management jobs has wiped out much of the proving ground for minorities and women. R. Roosevelt Thomas of the American Institute for Managing Diversity, argued in *Differences Do Make a Difference* that "corporations do not benefit from the full productive potential of some of their most able employees" if women and minorities are "limited by the continuing 'norm' of white able bodied males as the ideal" (Galagan, 1993b, p. 5l).

"For all the good that they do," wrote Galagan (1995b, p. 50), "diversity programs have yet to make a dent in what most experts consider to be the number one impediment to advancement for women and minorities: lingering and deep-seated prejudice." Myths about minority groups are part of what holds them back. A popular myth about women, for example, is that the environment will get better for them in the workplace in due time. A report called "Empowering Women in Business" by the Feminist Majority Foundation in Washington, DC, refuted this and other myths about women in business. According to Galagan (1995b), the report included evidence that equality at the top is not just a matter of time. According to the report, "it will take 475 years for women to reach equality with men in the executive suite" (p. 50).

As of 1993, women made up only 2.5% of top executive officers in Fortune 500 companies. More than half of the board chairmen of the Fortune 500 companies are the sons of former chairmen. According to the Associated Press (1996, p. C1), "about 100 of the Fortune 500 companies have no women corporate officers at all." In addition, a report by Catalyst (Associated Press, 1996) indicated that in 1995 only 1,303 of the top corporate officers (*n*=12,885) were women. And, of the 2,500 top wage earners, only 50 were women. According to Catalyst President Sheila Wellington, "there is still a glass ceiling, but equally important, this census documents the existence of glass walls" (Associated Press, 1996, p. C1). "Time alone will not cure this matter of women advancing to the top…We need vocal, sustained commitment from the top," said Wellington (p. C1).

"These and other hard-wired attitudes are behind the policies and practices that systematically restrict the opportunities and rewards available to women and people of color" contended Ann Morrison, co-author of *Breaking the Glass Ceiling and The New Leaders: Guidelines on Leadership Diversity* in America (Galagan, 1993b, p. 52). Ann Van Eron, principal of Potentials, an organizational development firm, noted that "diversity is likely to breed tension, conflict, misunderstanding and frustration unless an organization develops a culture that supports, honors, and values differences" (l995, p. 55).

An examination of the workplace and the conditions for women and minorities in business and industry will aid us in technology education as we examine the environment for women and minorities in our profession. Granted, the educational system is somewhat unique and often removed from the private sector but societal problems rarely exclude themselves from either venue.

THE TECHNOLOGY LEARNING ENVIRONMENT

Imagine a place where very little in the environment looks familiar. The language is different, and everyone or almost everyone around you looks different. That's the scenario for women and minorities when they enter many technology education programs. The room is probably filled with devices not seen at home or used previously in school. The terminology is so new and different that few words relate to daily life. There is also the isolation of being the "only child"—the only girl, the only Asian or Asian-American, the only African-American, etc. When a young woman or minority enters a technology education program, what does she or he experience?

To increase the enrollment of women and minorities in technology education at all levels, we must make the environment welcoming, supportive, and conducive to making the transition from the unfamiliar to the familiar. This requires technology educators to focus on their own awareness of the classroom/laboratory environment and to analyze carefully what restricts the entry and retention of women and minorities. Being different is not the "problem" of the young African-American girl who is captivated by lasers and robotics. Thus, she must not be forced into the mold of how White men learn about and gain experience with lasers and robotics. The educational environment must change to accommodate her and provide experiences with technology that relate to her daily life experiences. This accommodation requires curriculum innovations, new pedagogical approaches, and often a real change in how the instructor perceives and interacts with students.

CHALLENGES IN TECHNOLOGY EDUCATION

Public school systems throughout the United States engage thousands of students annually in the study of technology through technology education programs. Many students are college bound. These technologically literate graduates have many career options: business, communications, engineering, graphic design, industrial technology, medicine, physics, etc. Because of a wide range of interests, perceived lucrative salaries, or lack of awareness of technology education as a career, few students elect to major in technology education in college. A classroom teacher may find few students and their respective parents excited about the career of teaching technology. This problem, among other factors, has created a major shortage of technology teachers nationwide. Today technology teacher educators must recruit not only from high school technology education programs but from community colleges and undeclared majors already on campus. of the available students, a few women and minorities each year are compelled by high technology and the prospect of teaching children.

They enter into technology education thinking they will have a successful career. If they are lucky, a professor will mentor them through their college program. If not, they likely will encounter experiences with peers or faculty members that are inconsistent with the way they perceive they should be treated. Without a support system in place, these experiences begin to erode the student's ability to cope with the environment. Although the technology education program faculty may not intend to sustain a negative environment for women and minorities, it may still exist. In fact, it may even be invisible to the faculty yet obvious to the underrepresented groups enrolled.

Initial negative experiences cause many high-potential students from underrepresented groups to remove themselves from a program. The “make or break” practice of expecting women and minorities to assimilate causes some students to find other majors or even drop out of school. The need to excel beyond the “average” to be considered acceptable is also problematic. Essential for the retention of underrepresented groups are support systems and faculty who have a commitment to diversity and non-biased educational experiences. Student leadership activities for all technology education majors are also required. Technology teacher educators must also agree that what needs to be “fixed” is the system, which allows discriminatory practices to survive. Women and minorities who make it through the higher education system in technology education should be able to say that they succeeded because of their professors, not in spite of them.

The graduating teacher who happens to be a woman and/or minority is met with two scenarios when searching for a teaching position: the school system that is excited to attract and hire a new teacher from an underrepresented group, or the school system that won’t hire a new teacher from an underrepresented group (for whatever reason—e.g., perception of less ability, dominance of white men in the hiring process). The wise graduate takes a position at a school like that described in the former scenario, which seems most supportive of her or his teaching abilities and interests. What may result, however, is that the upper-level administrators who hired the new teacher are unaware or detached from the environment the teacher will encounter daily. That is, the manner in which the new teacher is initiated in the workplace by her or his new colleagues may not be what was promised during the hiring process.

Career induction can be a wonderful inclusionary experience, or it can be absolutely isolating. The new teacher may be hired into a group of technology teachers who have worked together for years, creating the possibility that being new and "different" increases the difficulty of "fitting in." The new teacher may be the sole technology teacher in the school, thus having the burden of being inducted into teaching by those who may not have an appreciation of technology education or what it is like to be a member of an underrepresented group.

Of course, not all situations are negative, and not all new teachers have a difficult time adjusting to the demands of teaching and their work environment. The point is that the environment can't be forgotten, and its influence on the retention of technology teachers from underrepresented groups cannot be overemphasized. The mere fact that we often don't realize a problem exists or we have created what is termed a "null" environment (an environment lacking in encouragement or support and thus restraining performance) is cause for examination of our practices and support systems.

Technology teachers from underrepresented groups have a keen sense of what has happened to them throughout their careers. What keeps them going is the hope that the environment will get better. Maintaining a positive view over the long haul isn't easy. After repeated negative experiences it's amazing that women and minorities remain in our profession. They do because of positive influences on their careers, the students who have touched their lives, the mentors and role models who have guided them when times were tough, and perhaps a persistent sense of dedication to the teaching profession.

ORGANIZATIONAL CULTURE

Technology education programs and even their discrete classes have a culture all their own. Departments, school buildings, and institutions have idiosyncratic characteristics. Professional associations and professions at large form their own operational style and environment. All represent what is termed organizational culture. Organizational culture has been defined as "the pattern of shared values and norms that distinguishes an organization from all others" (Higgins, 1994, p. 461). These values and norms provide "direction, meaning, and energy for members of the organization," according to Higgins (p. 462). Every organization and profession has a culture of its own that evolves as the members of the organization and their expectations change.

To increase the participation of women and minorities in technology professions, organizational cultures must be attractive to these individuals and consistent with the factors (values and norms) with which these individuals can best identify. To do this, technology organization such as educational institutions, professional associations, and business/industry must develop and reinforce organizational cultures that ensure and value diversity.

What kind of culture works best? According to Meares (1986), the specific needs of organizations differ. But in general, cultures should be created and managed such that they:

- Create and meet employee expectations
- Communicate desired values and beliefs
- Promote interdependence and mutual trust and respect
- Provide mentorship
- Sponsor advantageous directives and philosophies
- Encourage individuals to share their efforts and ideas freely (p. 58)

According to Deal and Kennedy in *Corporate Culture: The Rites and Rituals of Corporate Life* (Goldstein & Leopold, 1990, p. 55), "employees attain yet another sense of who they are, what they should be doing and how they should behave through identification with their organization's culture. The company benefits from this cultural cohesiveness, which is essential for smooth work flow, productivity and a common sense of affiliation that, in turn, contributes to the organization's values and goals…Mike Fenton, manager of affirmative action and human resources planning for AT&T's Bell Laboratories, says that people must be comfortable with each other to work well together."

Social scientists examine and describe organizational culture through four kinds of artifacts: myths and sagas; language systems and metaphors; symbols, ceremonies, and rituals; and identifiable value systems and behavioral norms. To focus on the relationship between underrepresented groups and organizational culture, we must become aware of the artifacts that currently define technology education organizations.

Myths and sagas reveal important historical facts about early pioneers and products, past triumphs and failures, and the visionaries who have transformed the profession (Higgins, 1994). These myths and sagas "identify the organization's shared values and norms and reinforce them"(p. 462).

What myths, sagas, stories, and history should be shared about the inception and growth of technology education? Such stories help to shape the attitudes and behavior of new and veteran members of an organization. If the myths and sagas of technology education include women and minorities, then the profession will be seen by new and potential members as one where all can succeed and gain self-esteem. If they can see that performance is rewarded and that the members of the profession care about them, the motivation for women and minorities to belong to the profession will be high.

Language systems and metaphors used in an organization also indicate shared values. How people refer to each other in professional settings and the language used can create the feeling of an open group or a closed society. Male-oriented language in technology education conveys subtle messages to women that may not be supportive of their inclusion. For example, calling someone by their last name is a masculine way to address them and is an unprofessional approach. Referring to members of a group as "guys" is another common masculine classification.

Symbols, ceremonies, and rituals reveal what is important to us. Symbols, logos, flags, and slogans convey the importance placed on certain ideas or events. Mottoes convey much about organizations and serve verbally as a symbol. According to Hersey (Higgins, 1994, p. 463), a good motto meets the following criteria:

- It conveys and promotes the organization's core philosophy.
- It has an emotional, rather than rational or intellectual appeal.
- It is not a direct exhortation for loyalty, productivity, quality, or any other organizational objective.
- It is mysterious to the public but not to members of the organization.

Value systems and behavioral norms are reflected in the profession's strategy, structure, systems, style, staffing, skills, politics, rules, and procedures (Higgins, 1994). Values and norms are passed on in informal communications and can also be seen in what is rewarded. How organizations are structured and the extent to which individuals are allowed to participate in decision making are a critical component of the value system.

Kilmann (1985) found that norms, or informal standards of behavior play an important part in establishing an organization's culture. About 90% of organizational norms have negative connotations. Findings by Kilmann suggested that culture, as expressed in norms, could have a negative effect.

IDENTIFIABLE CULTURES

Deal and Kennedy (1982) suggested four cultural categories: tough-guy/macho culture, bet-your-company culture, work hard/play hard culture, and process culture. Dr. Jeffrey A. Sonnefeld, Director of the Center for Leadership and Career Change at Emory University Business School, described four kinds of corporate culture: “the Academy, the Club, the Baseball Team, and the Fortress” (Strugatch, 1990, p. 206). These categories serve to describe the work environment and provide definition for why women and minorities may find some cultures foreign to them.

Tough guy/macho cultures are characterized by highly competitive situations with high-risk strategic decision making. Leaders in this type of culture are "heroes," slogans are “battle cries,” and “ceremonies focus on problem solving” (Higgins, 1994, p. 467).

Bet-your-company culture “results from decisions for which feedback is slow but risks are high” (p, 467), The culture is common in capital intensive areas where major investments are made in technology and equipment yet the payoffs are not known for some time. The “heroes” in this culture are wise and experienced because they have “survived over the long haul” (p. 467) and know what’s involved in believing in the organization. The ceremonies associated with this type of culture are formal meetings designed to reduce uncertainty.

The work hard/play hard culture “emerges in situations characterized by fast feedback and low risk” (Higgins, 1994, p. 467). It is considered to be a fast-paced and fun culture where there is plenty of action for everyone and creative problem solving is encouraged. Conventions, meetings, contests, and parties all reinforce the values of hard work and hard play.

The process culture “evolves from situations in which feedback is slow and risk is low” (Higgins, 1994, p. 468). The term process refers to how problems are solved and decisions made. According to Higgins, “the key value is the way in which decisions are made—that is, the process” (p. 468). Organizations with a process-oriented culture are often described as mechanistic. “Heroes” in this culture “devise new processes and perform maintenance roles for the organization” (p. 468), and they keep the organization going by passing on information. Ceremonies reward performance in carrying out the process, like 10-year or 2l-year awards.

The four categories postulated by Sonnefeld offer some additional possibilities (Academy, club, Baseball Team, and Fortress) and insights into the personalities that are attracted or best suited to different organizational cultures. The Academy directs organizational members to specialize and celebrates the value of personal training (or level of educational attainment). In the Academy, hierarchy is valued, and movement is vertical. The Academy encourages specialization and long-term commitment.

The club values versatility and helps organizational members be team players or "family." In the club, conformity is valued. Both the Academy and the club tend to attract individuals who value stability, enjoy a variety of challenges, and find they "shine" in group settings (Strugatch, 1990). In both settings, individuals know how to fit in quickly and are participative.

According to Strugatch (l990, p. 207), "if the club is an extended family, the Baseball Team is a one-night stand. You have to hit a homerun the very first week of the season or you're history." The baseball team values those who produce at all costs, even in a high-pressure environment with short-term results.

The fortress exists in a permanent atmosphere of crisis, expecting organizational members to thrive on it. Like the baseball team, the Fortress is for individualists, independent thinkers, and those with little regard for conventional wisdom. The fortress stresses instinct over training. The heroes at the baseball team and fortress are risk takers guided by their instinct and savvy.

These models from business and industry also relate to the cultures found in educational institutions and professional associations. To learn more about our organizational culture, we might ask these questions: What is the culture of the institution where I am affiliated and the culture of the professional associations in which I hold membership? What context(s) have been created by design or by default that influence people in these organizations and thus contribute to the dilemma of how to increase the involvement of minorities and women?

WHAT HAPPENS TO UNDERREPRESENTED GROUPS IN THESE CULTURES?

It is generally believed that people usually accept (or gravitate toward) organizational cultures that are like themselves and where they can feel comfortable and contribute. Researchers using questionnaires have recognized that many women have entered technology professions because of experiences they had early in life with their fathers (e.g., building or making things, or engaging in technological activity in a positive setting) or the influence/recommendation of their teachers. Somehow through experience in prior situations the "culture" was internalized as being attractive. If this is true, then we in technology professions must offer a broader range of contexts for which individuals of diversity can "fit" by changing the organizational culture, or we must attract those individuals with the personalities and interests that "fit" the organizational culture.

Recruitment is often seen as the means by which individuals can be brought "into the fold." In actuality, recruitment will only be beneficial if retention issues are addressed. For example, recent reports in the press have reported on women in science and engineering careers. An article from Knight-Ridder News Service reported that "women are leaving careers in science and engineering at almost double the rate of men and face a wo5k environment with unequal pay, sexism and few accommodations for family demands, according to a National Research Council Report" (1994, April 5, p. C2). The report, "Women Scientists and Engineers Employed in Industry: Why So Few?" indicated that the reasons for under representation include "an old boy's network that prevents women from finding out about choice jobs. Paternalistic attitudes keep women from getting career opportunities. And hostile superiors who place unreasonable hurdles on women seeking career advancement" (p. C2).

According to Delatte and Baytos (1993), if an organization intends to respect individuality, the underlying assumption is that people new to the organization must go through an assimilation process. "Through this process those who are different are welcomed into the organization but then expected to blend in-or alter their attitudes and behavior to suit the organization's homogeneous culture or management style" (p. 56). They also reported that many people "are growing increasingly dissatisfied with the assumption that adaptation is completely their responsibility or that there is value in only one style" (p. 56).

In some organizations token women are placed in positions of authority or influence by men who may believe that they are "doing the right thing." This weakens the relationships among professional women (Ely, 1994). In Ely's research on the effects of organizational demographics and social identity on relationships among professional women, she cited Kanter's (1977) analysis of the "queen bee syndrome" as being problematic: "Queen bees Ne token women in traditionally male-dominated settings whom male colleagues reward for denigrating other women and for actively working to keep other women from joining them" (Ely, 1994, p. 207).

In addition, Ely also reported "that white men's extreme overrepresentation in organizational positions of authority have a negative impact on women and nonwhite subordinates" (p. 207). Similarly, Ridgeway (l988) suggested that the disproportionate representation of men over women in senior organizational positions may highlight for women their limited mobility and reinforce their lower status as women, even in work groups composed entirely of women. "When this occurs, women form lower expectations for the positions women, and they as women, are likely to achieve in the organization" (Ely, 1994, p. 207).

Research by Morrison, reported in an interview by Galagan (1995b), indicated that the turnover rate for high-potential women is much higher than for high-potential men. Morrison reported that a common reaction to high turnover among women is to change the benefits package, because men believe that women leave to start families. "Thanks to research by Vicky Tashjian, we know that only 7 percent of female professionals and managers leave for family reasons. Of the rest, 73 percent leave because they see limited career opportunities for women in their companies" (p. 42).

Monsanto recognized it had an organizational problem when it discovered it had poor retention rates among people outside the mainstream culture (Galagan, 1995c). Monsanto found that minorities and women were leaving almost twice as often as white men. In the case of minority women, the rate was three to four times the rate for white men. Monsanto examined its structure and culture, which resulted in the identification of eight process barriers that prevented people from understanding diversity:

- Denial of issues
- Lack of awareness
- Restrictions on bringing bad news up the line
- A lack of trust about how others will perceive and respond to diversity issues
- The need to be in control in all areas of one's job
- A compulsion to fix "them" rather than "us"
- An issue outside one's reality
- Past, well-intended, diversity actions (p. 49)

Galagan (1995c) reported that a common reaction to difference is to "fix" the person whose behavior is different. Thomas Cummins, Diversity Development Director for Monsanto, said, "male managers send women to assertiveness training, hoping they will come back able to make their points and ask for things "the way a man does" (p. 49). Cummins said that, in an organization mostly made up of white men, "white-male reality is like water to fish—natural and invisible. So we can't understand why people are doing all these strange things to survive in an environment that's so comfortable for us" (Galagan, 1995c, p. 49).

According to Marshall Singer, author of *Intercultural Communications: A Perceptual Approach* (Goldstein & Leopold, 1990), "when surrounded by the so-called majority, people who belong to an ethnic or other minority group usually are unable to forget their minority identities. Internal as well as external conflicts may arise" (p. 85). Singer also noted that one part of women and/or minorities "argues for assimilation; the other side may resist, perhaps by expressing even stronger links to the minority identity group. In such a situation, ethnic identity can become more, not less pronounced" (p. 85). Ignoring our differences discounts our uniqueness as individuals.

CREATING A CULTURE CHANGE

According to Porter and Parker (l992, p. 45), "(o)rganizations which do not change will not survive." Increasing attention has been given to changing how work is done within the organization. When the fundamental ways in which work is done are changed, new strategies, structure, workforce, technologies, customers, and financial engineering become institutionalized, not idiosyncratic (Porter & Parker, 1992).

Changing the demographics of an organization is an important first step. But effective change will not occur unless diversity exists at all levels, a sound conceptual plan is in place, and the plan is supported vigorously (Anderson, 1995). Anderson contended that "different people feel differently about their roles in an organization, about the ways in which they can contribute, and about the recognition and rewards they receive" (p. 60). Anderson believed it is helpful to think about employees in terms of four styles: learning, human-relations, motivational, and communication. This effort will be more successful when processes "foster equity, consensus, and empowerment" (p. 60).

Is diversity really one of the key issues? Is our lack of diversity what causes the culture to change so slowly? When we recognize the value in diversity, perhaps our attention can be focused toward productive activity that will lead us to achieving the goal of enhanced participation for women and minorities in technology education.

There are many reasons why organizations are attending to issues of diversity. Rossett and Bickham (1994) reported that compliance, harmony, inclusion, justice, and transformation are all part of the diversity puzzle for organizations. "Compliance" reasons focus on legal aspects of equal opportunity, including racial and sexual discrimination. "Harmony" includes the desire to have people get along with one another and to appreciate each other. "Inclusion" targets underrepresented groups and helps members work with diverse colleagues. "Justice" eradicates the lack of efforts to correct for lack of diversity in the past. "Transformation" means changing the values, processes, and standards of organizational behavior.

According to Rossett and Bickham (l994, p. 4l), "(m)any seem to plunge in without giving much thought to their specific goals. At the most basic level, some organizations don't consider whether their purpose is to change individuals or the organization or both." Delatte and Baytos (1995) cautioned that efforts to diversify are "unlikely to be particularly effective if they are conceived and designed via the BOWGSAT method—that is, a Bunch of White Guys Sitting Around a Table" (p. 59). To respond to the concerns and issues of diversity there needs to be diverse input.

In 1990, R. Roosevelt Thomas, Director of the American Institute for Managing Diversity at Morehouse College in Atlanta, suggested ten steps for managing cultural diversity successfully so that no members of the organization experience an unnatural advantage or disadvantage (Higgins, 1994, p. 476):

1. Clarify your motivation.
2. Clarify your vision.
3. Expand your focus.
4. Audit your corporate culture.
5. Modify your assumptions.
6. Modify your systems.
7. Modify your models.
8. Help people pioneer.
9. Apply the special consideration test.
10. Initiate affirmative action.

Thomas contended that the managerial environment must change and help people to understand that a culturally diverse organization enables everyone to contribute to her or his greatest potential. Managing cultural diversity, said Thomas, "goes beyond integrating minorities and women into the work force. Its goal is to create a heterogeneous culture in which people differ in many ways, including age, education, background, function, and personality" (Higgins, 1994, p. 476).

To create the desired culture, information about the existing culture is needed, and the organizational culture's real values must be changed to meet the requirements of the new culture (Thomas, 1990). In the change process, members of the organization must be helped to "overcome obstacles and recover from failures" (Higgins, 1994, p. 476).

Bailey Jackson of the University of Massachusetts developed four basic principles that can be used to identify progress toward a multicultural organization (Jackson, LaFasto, Schultz, & Kelly, 1992). A multicultural organization:

1. Reflects the contributions and interests of diverse cultural and social groups in its mission, operations, and product or service
2. Acts on a commitment to eradicate social oppression in all forms within the organization
3. Includes the members of diverse cultural and social groups as full participants, especially in decisions that shape the organization
4. Follows through on broader external social responsibilities, including support of other institutional efforts to eliminate all forms of social oppression. (p. 22)

Jackson and Hardiman (Jackson et al., l992, pp. 22–24) identified stages that an organization may go through. Figure 12-1 illustrates these stages that an organization may move through as it becomes a multicultural organization.

LEVEL ONE

Stage One: The Exclusionary Organization

The Exclusionary Organization is devoted to maintaining dominance of one group over other groups based on race, gender, culture, or other social identity characteristics. Familiar manifestations of such organizations are exclusionary membership policies and hiring practices.

The Path from a Monocultural Club
to a Culturally Diverse Organization*
Judith H. Katz and Fredrick A. Miller

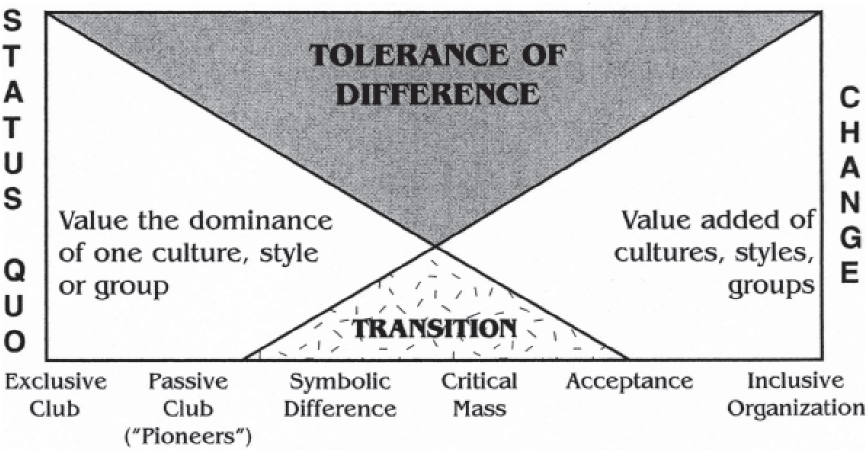

Figure 12-1.

*This model was originally developed by Bailey Jackson, Rita Hardiman and Mark Chesler (1981) "Racial Awareness Development in Organizations" and adapted in 1986 by Judith H. Katz and Frederick A Miller, the Kaleel Jamison Consulting Group, Inc.

Stage Two: The Club

The club describes the organization that stops short of explicitly advocating anything like White male supremacy, but does seek to establish and maintain the privilege of those who have traditionally held social power. This is done by developing and maintaining missions, policies, norms, and procedures seen as "correct" from their perspective. The Club allows a limited number of members from oppressed groups such as women and racial minorities, provided that they have the "right" perspective.

LEVEL TWO

Stage Three: The Compliance Organization

The Compliance Organization is committed to removing some of the discrimination inherent in the "club" by providing access to women and minorities; however, it seeks to accomplish this objective without disturbing the structure, mission, and culture of the organization. The organization is careful not to create "too many waves" or to offend or challenge its employees' or customers' racist, sexist, or anti-semitic attitudes or behaviors.

The compliance organization usually attempts to change its organizational racial and gender profile by actively recruiting and hiring more racial minorities and women at the bottom of the organization. On occasion, they will hire or promote "token" racial minorities or women into management positions, usually staff positions. When the exception is made to place a woman, racial minority, or member of any other oppressed social group in a line position it is important that this person be a "team player" and that s/he be a "qualified" applicant. A "qualified team player" does not openly challenge the organization's mission and practices and is usually 150 percent competent to do the job.

Stage Four: The Affirmative Action Organization

The Affirmative Action Organization is also committed to eliminating the discriminatory practices and inherent "rigged" quality of The Club by actively recruiting and promoting women, racial minorities, and members of other social groups typically denied access to our organizations. Moreover, the affirmative action organization takes an active role in supporting the growth and development of these new employees and in initiating programs that increase the chances of success and mobility. All employees are encouraged to think and behave in a non-oppressive manner, and the organization may conduct racist and sexism awareness programs toward this end.

This organization's view of diversity also includes the disabled, Latinos, Asians/Asian American-Pacific Islanders, Native Americans, the elderly, and other socially oppressed groups. Although the affirmative action organization is committed to increasing access for members of diverse groups and increasing the chances that they will succeed by removing those hostile attitudes and behaviors, all members of this organization are still required to conform to the norms and practices derived from the dominant group's world view.

LEVEL THREE

Stage Five: The Redefining Organization

The Redefining Organization is a system in transition. This organization is not satisfied with being just "anti-racist" or "anti-sexist." It is committed to examining all of its activities for their impact on all members' ability to participate in and contribute to the growth and success of the organization.

The redefining organization begins to question the limitations of the cultural perspective as it is manifest in its mission, structure, management technology, psychological dynamics, and product or service. It seeks to explore the significance and potential benefits of a diverse multicultural workforce. This organization actively engages in visioning, planning, and problem-solving activities directed toward the realization of a multicultural organization.

The redefining organization is committed to developing and implementing policies and practices that distribute power among all of the diverse groups in the organization. The redefining organization searches for alternative modes of organizing that guarantee the inclusion, participation, and empowerment of all its members.

Stage Six: The Multicultural Organization

The multicultural organization reflects the contributions and interests of diverse cultural and social groups in its mission, operations, and product or service; it acts on a commitment to eradicate social oppression in all forms within the organization; the multicultural organization includes the members of diverse cultural and social groups as full participants, especially in decisions that shape the organization; and it follows through on broader external social responsibilities, including support of efforts to eliminate all forms of social oppression and to educate others in multicultural perspectives.

Carr (1994) indicated that "individuals vary widely in their openness to and enthusiasm for change" and that "the person most comfortable with any particular change is the one proposing it" (p. 55). People resist being changed-especially when the change appears to have a payoff primarily for someone else. Carr contended that in order to change we must "understand the factors that matter in change and what impact they have on the people we expect to change" (p. 56). He proposed and described seven key factors (or questions) that play a role in the change process:

1. Is this change a burden or a challenge?
   "A change with a clear payoff for those who must do the changing will feel like a challenge. If it lacks such a payoff it will feel like a burden" (p. 56).
2. Is the change clean worthwhile, and real?
   "lf an organization presents a proposed change so that its benefits appear uncleal trivial or highly unlikely to materialize, the change almost certainly will be seen as a burden to be avoided. On the other hand, when the change promises clear, worthwhile and believable benefits, it will look desirable" (p. 56).
3. Will the benefits of the change begin to appear quickly?
   "The longer a change takes, the hazier its payoff will appear and the more it will seem a burden" (p. 56).
4. Is the change related to one function or a few closely related functions?
   "Nothing is more dear to the units of a traditional organization than preserving their functional integrity. The more functions that must cooperate to produce a change, the greater the probability that at least one function will see itself as a loser in the change and work to sabotage it" (p. 57).
5. What will be the impact on existing power and status relationships?
   "Many organizational players work assiduously to accumulate power and status. Even those with other goals normally appreciate having power and status. And those who have it unfailingly work to maintain it. If a change directly attacks the power and status of any function or group, those who profit from the established situation will certainly oppose it, overtly or covertly. The more that a proposed change conforms to the existing power and status structure, the less likely it is to be opposed by entrenched powers" (pp. 57–58).
6. Will the change fit the existing organizational culture?
   "Transformational changes fail more often than they succeed. Even when they're successful, the cost to the organization is always high and the payoff may be considerably less than expected. Furthermore, major changes almost always succeed only because the organization is facing a major crisis. Is the survival of your organization at stake? If not, then the better the change you propose fits the values of the existing culture, the better the chances of success. Even sweeping changes can be based on core values of the organization" (p. 58).

7. Is the change certain to happen?
"People are much more likely to get involved or to go along with something if they believe it is really going to happen. The point is simple: If you want something to change, line up enough organizational horsepower to ensure that it will before you start the change" (p. 58).

Because culture is often hard to define or articulate, it is usually difficult to develop practical approaches for changing an organization's culture. According to Craig (1993), even though we cannot change culture directly, we can use the elements of organizational design as levers. "By pushing these levers the right way, a company can create new attitudes and behaviors" (p. 16). These levers are:

- Organization structure—the formal relationship between workers
- Work processes-activities linked to accomplish a task or to produce a product
- Management and information processes-the vision, goals, and tasks of the organization and measurements of what employees are doing to meet these goals and tasks, including pay, incentives, and other rewards; planning; training; and formal and informal methods of communication
- Management and information systems-these include the computer applications used to collect, synthesize, and analyze data to produce information and distribute that information to employees

Comparison of Affirmative Action, Managing Diversity and Valuing Differences		
Affirmative Action	**Managing Diversity**	**Valuing Differences**
Quantitative. Emphasis is on achieving equality of opportunity in the work environment through the changing of organizational demographics. Progress is monitored by statistical reports and analyses.	**Behavioral.** Emphasis is on building specific skills and creating policies that get the best from every employee. Efforts are monitored by progress toward achieving goals and objectives.	**Qualitative.** Emphasis is on the appreciation of differences and the creation of an environment in which everyone feels valued and accepted. Progress is monitored by organizational surveys focused on attitudes and perceptions.

Legally driven. Written plans and statistical goals For specific groups are utilized. Reports are mandated by EEO laws and consent decrees.	**Strategically driven.** Behaviors and profiles are seen as contributing to organizational goals and objectives. such as profit and productivity, and are tied to rewards and results.	**Ethically driven.** Moral and ethical imperatives drive this culture change.
Remedial. Special target groups benefit as past wrongs are remedied. Previously excluded groups have an advantage.	**Pragmatic.** The organization benefits: morale, profits, and productivity increase.	**Idealistic.** Everyone benefits. Everyone feels valued and accepted in an inclusive environment.
Assimilation Model. Model assumes that groups brought into system will adapt to existing organizational norms.	**Synergy Model.** Model assumes that diverse groups will create new ways of working together effectively in a pluralistic environment.	**Diversity Model.** Model assumes that groups will retain their characteristics and share the organization as well as be shaped by it, creating a common set of values.
Opens doors. Efforts affect hiring and promotion decisions in the organization.	**Opens the system.** Jots affect managerial practices and peoples.	**Opens attitudes, minds, and the culture.** Efforts affect attitudes of employees.
Resistance. Resistance is due to perceived limits to autonomy in decision making and perceived Fears of reverse discrimination.	**Resistance.** Resistance is due to denial of demographic realities, the need for alternative approaches, and the benefits of change. It also arises from the difficulty of learning new skills. altering existing systems, and finding the time to work toward synergistic solutions.	**Resistance.** Resistance is due to a fear of change, discomfort with differences, and a desire to return to the "good old days".

Figure 12-2 Adapted from Lee Gardenswartz and Anita Rowe, *Managing Diversity: A Complete Reference and Planning Guide,* 1993.

According to Craig (1993), "there's no magic formula for creating the 'right' workplace environment" (p. l8). Successful organizations share these qualities:

- A clear, shared vision which embodies positive values and drives people's behavior
- Leadership which communicates and reinforces the values
- Organizational members must be a valued asset and control their environment
- Organization must be adaptable and posses mechanisms that allow members to respond quickly and positively to a changing environment
- Improvement should be made based on measurements which reinforce shared values

SUMMARY

"If you need an expert on what it takes to get ahead in a U.S. organization if you aren't a white male, try Ann Morrison, president of New Leaders Institute," wrote Galagan (1993a, p. 39). Her research on barriers that hold women back led to her 1987 book, *Breaking the Glass Ceiling. Her latest book, The New Leaders: Guidelines on Leadership Diversity in America*, was the result of studying 16 model organizations. These organizations included 12 private- sector businesses, 2 government agencies, and 2 educational institutions. Some of these were American Express Company, Colgate-Palmolive Company, DuPont, Fairfax County (VA) Public Schools, Gannett, Kaiser Permanente, Michigan Bell, Motorola, the Palo Alto (CA) Police Department, U.S. West, and Xerox Corporation.

According to Morrison, in an interview by Galagan (1993a, p. 40), "unless the responsibility for advancement is shared, even women who make themselves into superwomen won't be accepted in some organizations." Morrison found that "the single biggest barrier to advancement is prejudice-equating a difference with a deficiency" (p. 40). The next five barriers to advancement were poor career planning; a lonely, hostile, unsupportive working environment; lack of organizational savvy; greater comfort in dealing with one's own kind; and difficulty in balancing family and career. These factors and others are the direct result of learning and work environments as well as organizational cultures that do not value women and minorities nor understand the important contributions made by women and minorities.

Within the technology education profession, we must take action to discover and rediscover problems in our learning and work environments, strengthen our commitment to women and minorities in technology education, choose solutions that fit a balanced strategy, demand results and revisit regularly our goals and plans, and use successful approaches and achievements to maintain momentum.

Conceptually and demonstratively, we must work through a model of diversity that moves us well past an emphasis on compliance and management to a level where valuing diversity is prominent in the thinking and action of technology education professionals. Then we will ensure individuals from underrepresented groups will feel comfortable with their learning and work environment. Thus, they will feel more confident in their ability to contribute. When people contribute, they are more productive, and the environment within the profession will enable us to become a high performance organization. As Margaret Mead noted, "If we are to achieve a rich culture, rich in contrasting values, we must recognize the whole gamut of human potentialities and so weave a less arbitrary social fabric, one in which each diverse human gift will find a fitting place."

REFERENCES

Anderson, J. A. (1995, April). Thinking about diversity. *Training & Development,* 47, 59–60.

Associated Press. (1996, October l). Women's climb to top of business ladder slow. *The Pantagraph,* pp. C1, C4.

Can, C. (1994, February). 7 keys to successful change. *Training*, 55–58, 60.

Craig, P. P. (1995). Pushing the right levers—The right way. *Journal of Business Strategy,* 14, 16–20.

Deal, T. E., & Kennedy, A. A. (1982). Corporate culture: Rites and rituals of corporate life. *Reading,* MA: Addison-Wesley.

Delatte, A. P., & Baytos, L. (1993, January). Guidelines for successful diversity training. *Training,* 55–56, 58–60.

Dovidio, J. (1995, April). The subtlety of racism. *Training & Development,* 51–57.

Ely, R. J. (1994). The effects of organizational demographics and social identity on relationships among professional women. *Administrative Science Quarterly,* 39, 203–238.

Galagan, P.A. (1993a, April). Diversity. *Training & Development,* 39–43.

Galagan, P. A. (1993b, April). Navigating the differences. *Training & Development,* 47, 29–33.

Galagan, P. A. (1995c, April). Trading places at Monsanto. *Training &, Development,* 47, 45–49.

Goldstein, J., & Leopold, M. (1990). Corporate culture vs. ethnic culture. *Personnel Journal,* 69, 83–92.

Higgins, J. M. (1994). *The management challenge.* New York: Macmillan.

Hughes, K. (1992, February). The fraying of America. *Time,* 31, 44–49.

Jackson, B. W., Hardiman, K., & Chesler, M. (1981). *Racial awareness development in organizations.*

Jackson, B. W., LaFasto, F, Schultz, H. G., & Kelly, D. (1992, Spring/Summer). Introduction: Diversity, an old issue with a new face. *Human Resource Management,* 31(1 & 2), 21–34.

Kanter, R. M. (1977). *Men and women of the organization.* New York: Basic Books.

Kilmann, R. H. (1985, April). Corporate culture. *Psychology Today*, 62–65.

Knight-Ridder News Service. (1994, April 5). Women leave careers in science, engineering. *The Pantagraph,* p. C2.

Meares, L. B. (1986, July). A model for changing organizational culture. *Personnel,* 63, 38–42.

Porter, B.L, & Parker, W. S. (1992, Spring/Summer). Culture change. *Human Resource Management,* 5l (l e 2), 45-67.

Ridgeway, C. L. (1988). Gender differences in task groups: A status and legitimacy account. In M. Webster & M. Foschi (Eds.), *Status generalization: flew theory and research.* Stanford, CA: Stanford University Press.

Rossett, A., & Bickham, T. (1994, January). Diversity training: Hope, faith, and cynicism. *Training*, 41–42, 4345.

Strugatch, W. (1990, September). You & co: If you and your company have matching personalities, you'll get ahead-fast. *Self*, 206–210.

Thomas, R. R. (1990, March-April). From affirmative action to affirming diversity. *Harvard Business Review,* 107-117.

Van Eron, A. M. (August, 1995). Ways to assess diversity success. *HR Magazine,* 51, 52.

Students

Section IX

STANDARD 9—STUDENTS
Technology teacher education program candidates understand students as learners, and how commonality and diversity affect learning.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 9. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Design technology experiences for students of different ethnic, socioeconomic backgrounds, gender, age, interest, and exceptionalities. • Identify how students learn technology most effectively by integrating current research about hands-on learning and learning about the content of technology.
Performance Indicators:
• Create technology experiences for students with different abilities, interests, and ages about the content of technology.
Disposition Indicators:
• Develop productive relationships with students so that they become active learners about technology and enhance their human growth and development.

Do We Teach Technology? Yes, But We Also Teach Kids!

Chapter 13

Richard D. Seymour
Ball State University
Muncie, Indiana
49th CTTE Yearbook, 2000

Most of us teach technology courses on a regular basis. We cover production topics, or teach about design, or evaluate technological impacts in our various classes. We run laboratory activities and show videotapes and grade homework. As technology educators, we spend a lot of time on computers and routinely fix machinery in our laboratories.

This scenario sounds like a characterization of a typical technology teacher—doesn't it? The daily agenda varies little from the intended lesson or planned activity. If a flow chart was established, one might identify steps such as planning instruction, organizing content and activities, introducing assignments, running the activities, summarizing each topic, and evaluating student progress towards achieving outcomes. All very clean—all right out of a collegiate methods textbook.

Of course, this view of the teaching profession, and of technology education in general, is not so simple in this age of change. Today's society is different from those of past decades, and so are the individuals who show up every day for our classes—our students. Schools have taken on new challenges, from dealing with troublesome behaviors to providing social services. Technology teachers must learn to function in this complex, often turbulent environment that is so prevalent today.

As teachers and managers of education, we often get lost in the daily routine of classroom instruction, curriculum issues, and extracurricular assignments. We forget we are teachers of young learners first, and professional technology educators second. This applies to us equally on a personal and school level. Mulgan (1997) noted that one center for Clinical Infant Programs reported that "the seven most critical qualities that children needed in order to do well at school included: confidence, curiosity, intentionally (the wish to have an impact), self-control, relatedness, the capacity to communicate, and cooperativeness. Most, in other words, turned out to be social skills, skills of managing connections" (p. 140). Sure, teaching about technology is important, but we must also focus on the youngsters in our technology classes.

Numerous educational studies describe the changing social and cultural demographics in today's schools. These reports cite the growing number of at risk students including those who are exposed prenatally to drugs or alcohol, those who are exposed to abuse at home, or still others who go to bed hungry night-after-night. Children from impoverished communities, plus single or no parent homes, are also considered at risk by several authors. Students in these situations face problems with social relationships as well as substantial learning difficulties. For instance, research clearly suggests that poor communication skills and impulsivity are associated with fetal alcohol exposure in children (Stevens & Price, 1992).

Unfortunately, this diverse population of learners is showing up at schools that are set up on the industrial-age model of education. The school day is fairly rigid, with most instructors teaching at least five classes each day. There is little opportunity in a standard 45-50 minute class period to give individual attention to the dozens of students that attend classes. It's perhaps understandable that teachers use a "fixed, predetermined curricula, with no allowances for situational modification" (Noblit, Rogers, & McCadden, p. 681) in surviving the daily demands of instruction and classroom supervision.

As technology educators, most of us have experienced a diverse group of students in our classes. At one end of the social spectrum are the computer nerds that excel at hands-on applications, yet often have limited personal skills. On the other hand, many students are routinely assigned to technology classes because school personnel consider the area a dumping ground for troubled students. Delinquent and challenged learners are routinely assigned to elective courses (especially the hands-on programs in the technology area). This assortment of personalities and backgrounds makes it challenging to work effectively with more than a few students in any single class period.

Yet to be mentioned are the personal difficulties or tragedies that mar the life of children today. With the teenage suicide rate climbing and the abuse of drugs and alcohol by youngsters increasing, almost everyone can identify someone who has faced a life-changing crisis at an early age. Crime, violence, and adult situations are all too normal in today's society. As a result, teachers interact directly with many emotional and bewildered students on a daily basis.

Berliner and Biddle (1995) remind us "that American schools must be prepared to help a lot more educationally disadvantaged students over the next few years" (p. 277). At risk populations, students from varying cultures, or simply the number of youngsters trying to cope with a personal dilemma will continue to increase in our secondary schools. Baring a major overhaul in the structure of schooling, educators must strive to build better relationships with their students within the existing constraints of the curriculum and daily agenda. The importance of a caring and supportive classroom is reflected in Noblit's et al. (1995) observation that "no one can reach his or her full potential without social skills, a feeling of self-worth, strong academic and cognitive activities, and nurturance and support" (p. 683).

Technology teachers need to address the specific needs, concerns, desires, and social skills of all students. It's not an option that we simply work on curriculum all the time, yet ignore the human beings that enroll in our classes. As the 1991 SCANS report noted, technological content and process are important, but so are the development of personal characteristics and foundational skills.

Educators, and technology teachers in particular, tend to blame the problems associated with modern schooling on the inputs, or the students who enroll in their classes. We need to stop complaining about negative trends or conditions and focus on deficiencies of the school system (especially those related to the needs and issues of our students). Technology teachers must foster a supportive and caring philosophy that includes all students. Noblit et al. (1995) observed that "caring fosters this teacher/student connection and encourages possibilities for learning that may not otherwise occur" (p. 683).

It is fairly easy to implement lessons that promote academic understanding and personal development. For example, a cooperative spirit is enhanced when group (or team) problem solving activities are used in addressing specific opportunities. A sense of community is established when activities focus on local needs and issues like designing a park for an impoverished neighborhood or creating a recycling program for the school. Students might better understand the challenges facing the wheelchair bound if assigned to create an accessibility plan for an existing structure. Sometimes student development comes about in creative ways, such as through a student club activity or service project. Numerous examples of laboratory activities based on human wants and needs are found in technology textbooks, in state or provincial guides, or on the Internet.

Mulgan (1997) suggested that "a curriculum fit for a more connected world would place a much greater emphasis on relationships" (p. 143). This concept is true of both personal and systems level associations. Due to the increasing complexity of technologies, most modern ventures require a team effort. Whether it's a flight crew or a product development team in a Fortune 500 company, both must function within the constraints of a global scenario. Even teaching in a technology education program demands new group skills and knowledge of evolving practices in order to succeed in the changing school environment.

In another example of interrelationships, our global information networks provide routine communication with others. Students also have access to digital scanners, color reproduction equipment, and audio equipment. Knowledge may be shared and gained more easily than ever before in our history, yet this same media that permits an open exchange of text and images requires cultural sensitivity and restraint. Technology educators must make it clear what is admirable versus unacceptable. Gerstner, Semerad, Doyle, and Johnston (1994) stated that "just as schools cannot run if students are not well-behaved, students cannot succeed in school—or life—if they fail to learn habits of self-restraint, forbearance, and delayed gratification…skills and values as basic as learning to count or to speak English" (p. 193).

Today's schools and educational practices have made teaching a complex, yet often casual task devoid of student attention. This is especially true in technology programs where an evolving curriculum has become the prime focus over the past decade. Little time has been spent learning about the students who show up in our classes on a daily basis, including a focus on their questions and their strengths and needs. Unfortunately, more often than not, academic growth (or progress) has been measured solely by answers to cognitive responses on examinations.

Sure, we teach our subject matter in an exciting, hands-on manner. And yes, we provide a laboratory full of new equipment and materials. But we also teach youngsters that are curious, eager to learn and grow, and uncertain about their technological world. We must spend time learning about them, addressing personal and social needs as well as the demands of the curriculum. Our attention to the learner deserves a position of prominence and importance on technology education's 21st century agenda. Don't you agree?

REFERENCES

Berliner, D. C. & Biddle, B. J. (1995). *The manufactured crisis: Myths, fraud, and the attack on America's public schools.* Reading, MA: Addison-Wesley.

Gerstner, L. V. Jr., Semerad, R. D. Doyle, D. P., & Johnston, W.B. (1994). *Reinventing education: Entrepreneurship in America's public schools.* New York, NY: Dutton Group.

Mulgan, G. (1997). *Connexity: How to live in a connected world.* London, UK: Chatto & Windus.

Noblit, G. W., Rogers, D. L., & McCadden, B. M. (1995, May). *In the meantime, the possibilities of caring.* Phi Delta Kappan, 76(9), 680-685.

Stevens, L. J. & Price, M. (1992, September). *Meeting the challenge of educating children at risk.* Phi Delta Kappan, 74(1), 18-23.

Technology Teacher Education in the United States

Chapter 14

Mark Sanders
Virginia Polytechnic Institute & State University, USA
55th CTTE Yearbook, 2006

INTRODUCTION

In contrast to education in many countries, public schooling in the United States (US) is a matter left largely to the states and local school divisions. The funding pattern for public education underscores this fact. Only about 7% of school funding derives from the federal government, while the remaining 93% is split somewhat evenly between state and local governments. Thus, most decisions about what is taught and how it is taught are made by state and local decision-makers. There is no such thing as a 'national curriculum' in the US, and teacher licensure regulations are established independently—and therefore somewhat differently—in each of the 50 states.

Over the past two decades, educational reform efforts have resulted in both national and state standards in all of the 'academic' subject areas, including mathematics, science, social studies, and language arts. Nationally developed standards, including the *Standards for Technological Literacy* (STL, ITEA, 2000) are essentially a set of recommendations developed and championed by professionals within school subject disciplines, working in cooperation with their professional associations. Individual states and localities are at liberty to determine the extent to which they incorporate any or all of the ideas embedded within those nationally developed school subject standards. So, while the STL have been well-received by the profession and will influence the field in many ways over the coming decades, they remain a set of recommendations rather than a set of required content standards.

In contrast to the recommended nationally developed standards, nearly all states have mandated standards in the academic subject areas, including English, mathematics, science, and social studies. Spurred by a nationwide 'accountability' movement, states are requiring all students to take statewide assessments in these academic subject areas. This is causing local school divisions to focus resources on the academic subjects, potentially to the detriment of elective subjects such as Technology Education (TE). Technology educators in several states have been successful in getting language which addresses the study of technology incorporated into their state standards. But even in these states, it has not yet resulted in statewide mandatory enrolment in Technology Education courses beyond a relatively brief middle school experience. Some local school divisions have countered the state standards movement with publications that claim specific Technology Education learning experiences help students achieve specific state standards–such as those in mathematics and science. But here again, that strategy has not resulted in compulsory Technology Education courses.

Many state departments of education and some local school divisions employ Technology Education teachers, teacher educators, and/or curriculum specialists to develop curriculum guides. These developers have the option of using the STL to guide them in this work, but once again, this is voluntary. In 1998, the International Technology Education Association established a Center to Advance the Teaching of Technology and Science (CATTS) to develop curriculum materials based upon the STL. Currently, just 12 of the 50 state departments of education hold an annual subscription to CATTS, which allows these states to distribute CATTS publications developed during their subscription year to Technology Education teachers throughout their states—this is also very different from a 'national curriculum.' In many states, Technology Education is administered under the umbrella of vocational education (Career and Technical Education, CTE), for historical reasons explained later in this paper. This administrative practice has often influenced decisions with respect to Technology Education curriculum and teacher licensure.

For all of the aforementioned reasons, Technology Education teacher licensure, curriculum, and practice in the US vary significantly from state to state and from one local school division to another. Despite these differences and the various efforts to infuse Technology Education into the school curriculum, the average student in the US currently gets only a brief exposure, if any, to Technology Education throughout 12 years of compulsory education.

The Structure of Technology Education in the US

Technology Education as an Elective Subject in Grades 6–12

Technology Education is, for the most part, an elective (optional) subject in grades 6–12. The primary exception to the elective nature of Technology Education courses occurs at the middle school level (grades 6–8), where in many localities, all students are required to enrol in a Technology Education course–though typically only for 6–18 weeks in duration. These courses generally introduce students to a wide range to technologies, with course titles such as Introduction to Technology, Inventions and Innovations, or Technological Systems. Due largely to the impact of digital technologies and entrepreneurship, many of the 'general laboratories' of the 1970s have been replaced by 'modular laboratories.' These typically consist of 6–15 modules, each of which provides students working in pairs with an activity representing the different technological systems (for example, information and communication, transportation, power and energy, manufacturing, construction, medical, and agriculture and bio-related technologies).

At the high school level, Technology Education is an elective subject. Although a few states, such as Maryland, lay claim to a state-legislated Technology Education requirement, there are far too few Technology Education teachers to deliver on this mandate. In the few states in which this state-legislation has occurred, courses other than Technology Education are routinely substituted for Technology Education, to comply with the requirement. Several states, such as New York and Massachusetts, are attempting to integrate technology standards with science and mathematics standards. In practice, however, the very limited number of Technology Education teachers across the K–12 continuum (including virtually none at the elementary grade levels) typically results in other teachers, such as elementary or science, addressing the technological component in very limited ways.

Technology Education in Grades K–5

Where implemented, elementary school Technology Education is generally highly regarded by those closest to the action: teachers, students, parents, and school administrators. But without a public mandate, these successes have been difficult to sustain over time, and no states address Technology Education as a stand-alone subject in grades K–5. There have been efforts to incorporate the study of technology into elementary grades since the early 19th century (see, for example, Battle, 1899; Bonser and Mossman, 1923; Gerbracht & Babcock, 1969; Miller and Boyd, 1970; Scobey, 1968; Winslow, 1922). A relatively small number of individuals–teacher educators, state supervisors, and elementary teachers have kept elementary school Technology Education alive through pre-service teacher education courses, in-service workshops with elementary teachers, and funded curriculum projects. The Technology Education Council for Children, a division of the International Technology Education Association (ITEA) has provided leadership for elementary school Technology Education in the US and is the primary force behind Technology and Children, an ITEA serial publication that focuses solely on elementary school Technology Education. Despite these efforts, elementary school Technology Education remains very sparse in the US.

HISTORY

In the last quarter of the 20th century, Technology Education emerged from Industrial Arts (IA) education, emphasizing different purposes than those championed in the IA era (Sanders, 2001). In the early years of the 20th century, encouraged by the work of John Dewey and the progressive education movement, a growing number of educators believed a general course of study that addressed industry and related social issues would benefit all students as citizens of our democratic society in the industrial age. This perspective was exemplified in Bonser and Mossman's (1923) definition of IA, as "… *a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes.*" Those who aligned philosophically with Bonser & Mossman's interpretation worked toward different general education goals than those in manual training who espoused a vocational approach to the curriculum. The Smith-Hughes Vocational Education Act of 1917, the first federal funding for any component of public education in the US, supported vocational education as a means of providing a new source of industrial workers in America. This legislation further encouraged the two factions to split along philosophical lines into what became vocational education and IA education. Vocational educators used the federal funding and Smith-Hughes' philosophy to develop trade and industry education and other vocational subject areas for some students, while IA educators continued to promote general education ideals and curriculum for all students.

Following World War II, leaders in the field began to study the idea of a curriculum grounded in the concepts of 'technology' rather than 'industry,' a trend initiated with William E. Warner's 1947 presentation titled *A Curriculum to Reflect Technology* (Warner, Gary, Gerbracht, Gilbert, Lisack, Kleintjes, and Phillips, 1947). In 1985, following four decades of professional dialogue, the American Industrial Arts Association changed its name to the ITEA. Since then, most programs in schools have followed suit (Sanders, 2001), though in practice, there remain widely varying approaches to Technology Education curriculum, content, and method.

While leadership in the profession espoused a general education philosophy, practice continued to focus largely on tool skills into the 1980s (Dugger, Miller, Bame, Pinder, Giles, Young, & Dixon, 1980; Schmitt & Pelley, 1966). This emphasis on tool skills and prevocational goals has always been a source of ambiguity in the profession (Lewis, 1996; Sanders, 2003). Leaders in the late 1960s successfully lobbied for the inclusion of IA in the 1972 Vocational Education Act, and within a few years, fully three quarters of the states were using federal vocational monies to fund some aspects of IA (Steeb, 1976). This trend and the accompanying philosophical ambiguity continue today, with 83% of the responding states reporting the use of monies provided by the federal vocational legislation for Technology Education (Sanders, 2003).

Over the past two decades, the ITEA has steadfastly promoted the new Technology Education agenda. Three ITEA publications have been instrumental in the transition from Industrial Arts to Technology Education: *Conceptual Framework for Technology Education* (Savage and Sterry, 1990); *Rationale and Structure for the Study of Technology;* (ITEA, 1996); and *STL: Content for the Study of Technology* (ITEA, 2000). State departments of education, technology teacher education programs, and local school divisions have begun to use these as they upgrade their curricula.

OVERVIEW OF TECHNOLOGY TEACHER EDUCATION

Technology teacher education (TTE) began to emerge in the late 19^{th} century. In 1886–87, a manual training laboratory/course was established at the State Normal School[1] at Oswego, New York (NY). A year later, NY state legislation established similar manual training teacher education programs in normal schools throughout the state *(Industrial Arts Teacher Education at Oswego to 1941).* Manual Training/IA teacher education programs subsequently developed at normal schools throughout the US.

Estimates of the number of technology teacher education programs and graduates have historically been made from data culled from the *Industrial Teacher Education (ITE) Directory.* Because the *Directory* now includes many programs that do not prepare teachers, estimating the numbers of technology teacher education programs and graduate requirements is somewhat subjective. To get a reasonable estimate of the current numbers, the data in the 2004–05 *ITE Directory* (Schmidt and Custer, 2004) was reviewed. Institutions that listed Technology Education graduates, Technology Education licensure candidates, faculties identified in the *Directory* as having technology teacher education responsibilities, and/or programs known to be a recent source of Technology Education graduates, even if none of the aforementioned criteria were met, were considered 'active' technology teacher education Programs. Using those criteria, the author identified 70 technology teacher education programs as currently active. This group included at least seven programs the author deemed 'questionably active.'

Historically, there have been four large technology teacher education programs in the US: State University of New York at Oswego, the University of Wisconsin–Stout, Millersville University of Pennsylvania, and California University of Pennsylvania. Anecdotally (and historically), these four institutions have been said to produce about one fourth of the technology teacher education graduates each year. For the 2003–2004 year, these four institutions reported a combined 209 of the total of 550 Technology Education baccalaureate degrees reported (by the 42 institutions who reported Technology Education baccalaureate degrees in the 2004–2005 *ITE Directory*). That works out to an average of 13.1 Technology Education graduates per institution. The other 38 institutions reporting

[1]Normal schools were state-funded schools specifically established for public teacher education. The first Normal School was established in Massachusetts in 1839.

Technology Education baccalaureate data in the 2004–05 *ITE Directory* (for the 2003–2004 year) accounted for a combined total of 341 graduates (an average of 9.0 Technology Education graduates per institution). Assuming the 28 non-reporting institutions averaged 9.0 graduates per institution (likely an overestimate for those non-reporting institutions), the 70 technology teacher education institutions in the US would have produced an estimated total of 802 Technology Education baccalaureate degrees in 2004. Finally, it is worth noting that there are some states that have no technology teacher education programs.

STRUCTURE OF TECHNOLOGY TEACHER EDUCATION

Most of the estimated 70 technology teacher education programs in the US operate four-year undergraduate baccalaureate degree programs leading to Technology Education licensure. A relatively small, but increasing percentage of Technology Education teachers are prepared through fifth year, masters/licensure, and alternative licensure models described below.[2] Technology teacher education programs are found in all types of four-year post secondary institutions and are housed in a wide range of administrative units, including colleges, schools, or departments of education, arts and sciences, applied science and technology, technological studies, engineering, and human resources.

Technology teacher education in the US consists of three components: general education, pedagogy/professional education, and technical coursework. The general education component is a core of courses that most colleges/universities require of all students, regardless of the field they choose to pursue. These courses are typically arts and science courses in English, mathematics, social science, natural sciences, and the humanities. These general education courses are decided upon by university communities and are taught, for the most part, by faculty in the arts, sciences, and humanities.

The pedagogy/professional education component of the technology teacher education curriculum generally includes courses in educational foundations (for example, the historical, philosophical, and social foundations of education), educational psychology, curriculum development, and

[2]A significant, yet unknown, percentage of current Technology Education teachers do not hold a valid Technology Education teaching license. They are employed on a "provisional" basis and in theory, at least, must be terminated after three years in this status if they do not earn licensure.

instructional methods. Education majors representing all of the subject areas typically enroled in the educational foundations and educational psychology courses concurrently, while the Technology Education faculty commonly teach curriculum and methods courses to Technology Education majors. In addition, the pedagogy/professional education component generally includes early clinical education experiences prior to student teaching, which typically occurs during the final year of the program.

The third component of technology teacher education comprises a wide range of technical courses that provide the technical knowledge and skills needed to be an effective Technology Education teacher. Historically, these courses were taught by IA teacher educators and included technical content typically taught to students in grades 6–12, along with more advanced technical content. Currently, it is more common for these courses to be taught by highly technical faculty working in a non-teaching degree program, such as Industrial Technology, with content that is likely to be more technical than that taught at the secondary school level.

In practice, these three components of teacher education have been delivered in different configurations (Custer and Wright, 2002; Householder, 1993; Zuga, 1997). Following are brief descriptions of the most common technology teacher education models currently implemented in the US.

Technology Teacher Education Models

Traditional Four-Year Technology Teacher Education Model

Until the 1970s, the IA education faculty generally had responsibility for teaching both the in-major pedagogy/professional courses (curriculum, method, and clinical experiences) as well as all of the technical content courses. The technical courses in this model included the content and experiences one might expect to teach in a middle or high school program, as well as some additional content of greater technical sophistication. Until the late 20th century, virtually all of these technology teacher education faculty members had risen through the ranks of public (government) school teaching, so they had a very good understanding of what their students would encounter in the public schools upon graduation. They developed

---

Sander, Theodor: Structural aspects of teacher education in Germany today—a critical view. In: http://tntee.umu.se/publications/te-structure.html.

both the technical and pedagogy/professional education courses with that idea clearly in mind. Textbooks used in the technical courses were often the same texts used in high school courses, in part because they were helpful in preparing students for the future, and partly because the technology teacher education market was too small to support a different set of post-secondary technical books.

Split Faculty Model

Success of the technical, non-teaching degree options that were widely introduced in the 1970s led to a gradual, but significant change in the structure of technology teacher education in the majority of programs throughout the US. As the numbers of non-teaching (for example, Industrial Technology) students/majors quickly surpassed the numbers of Technology Education teaching students/majors, there was impetus to hire faculty for their industry experience and technical expertise rather than for their experience in the public school classrooms. By the 1990s, this new professoriate tailored their technical courses for the non-teaching majors, such as Industrial Technology, which typically outnumbered the teaching majors, sometimes by a very wide margin. Teacher education majors in this split faculty model enroll alongside the non-teaching majors in these technical courses, which are designed primarily to prepare students for industry. Typically, the equipment and processes taught are more sophisticated than would be appropriate for grades 6–12. These programs generally employ a small percentage of Technology Education faculty with public school teaching experience, who are responsible for teaching the pedagogy/professional education courses and supervising the clinical experiences in education. This split-faculty model now dominates the technology teacher education landscape in the US.

Fifth Year Model

Post-secondary teacher education reform efforts in the 1980s promoted the idea of delivering professional education courses in a fifth year of post-secondary education to students who had earned baccalaureate degrees in the disciplines for which they were seeking teaching licensure. For example, a student might earn a baccalaureate degree in mathematics, and then

http://www.comenius.de/projecktedetail.cfm?id enroll in a fifth year program that would lead to teaching licensure in mathematics. Under this model, technology teacher education programs would likely draw upon engineering graduates to enroll in a fifth-year licensure program, as engineering is the closest discipline to Technology Education. For a variety of reasons, including the fact that engineering graduates have generally been in great demand in the workplace, this model has not been widely implemented in technology teacher education.

Masters/Licensure Model

Many technology teacher education programs have long offered a masters/licensure option for students who already had baccalaureate degrees from various fields other than Technology Education. These masters/licensure programs generally require many of the undergraduate Technology Education courses to fulfill most of the licensure requirements, though some of the graduate courses may also 'double count' for licensure, lightening the course load somewhat. It has become common to structure these programs so students may earn a masters degree while concurrently fulfilling teacher licensure requirements, a process that can take two and a half years to complete. These masters/licensure options generally require at least two years for completion, depending upon the prior degree/course history brought in by each individual student.

Alternative Licensure Models

In the 1990s, critical teaching shortages in many different school subject areas led to the development of alternative teacher licensure models throughout the US. These are essentially shorter streamlined paths to teaching licensure implemented at the state level, and sometimes are administered separately from the post-secondary teacher education programs in the state. There are currently a wide variety of alternative technology teacher education models in use (Litowitz, 1998; Litowitz and Sanders, 1999). In virtually all cases, these alternative Technology Education licensure options require a baccalaureate degree. Students in these options typically receive the professional education component and a relatively small number of technical content course hours. The student teaching experience is generally eliminated, and instead, a teacher/mentor is assigned to the first-year alternatively licensed teacher. In most states, those completing alternative licensure options must also pass exams that measure their professional education and discipline-specific knowledge, such as the Praxis I and II exams (Educational Testing Service, 2004). Typically, this alternative license is renewable within the state if additional education requirements are completed and upon successful completion of one or more years of teaching, though reciprocity agreements from one state to another may not apply to alternative licensure routes.

Trends in Technology Teacher Education

Standards for Technological Literacy

Throughout the US the *STL* (ITEA, 2000) have begun to facilitate change in technology teacher education programs. This change ranges from the subtle inclusion of new *STL* content in teacher education courses, to the complete restructuring of teacher education programs. *STL* certainly provides the impetus for an expansion of technological content and a rethinking of instructional method. Emphases on the study of design, the nature of technology, and the interaction between technology and culture, open the possibilities for reconceptualizing instructional activities. There is potential for greater emphasis on *knowing*, arguably with a corresponding decreased emphasis on *doing*, since perhaps a third of the standards focus upon cognitive understandings rather than on the tools and materials that have dominated the pedagogy of the profession over the past century.

Teacher Shortages

Significant teacher shortages have been a serious problem in the field for decades. In the 1970s, partly in response to the declining numbers of teacher education majors and partly in response to the substantial industry demand for their graduates in industry, many IA programs across the US began to offer non-teaching degree options, such as Industrial Technology. In general, their teacher education enrollments had been declining markedly, while their non-teaching option enrollments grew dramatically. Volk (1993) found graduates from these non-teaching options increased from 894 in 1970 to 7,063 in 1990. The movement to non-teaching options helps to explain the escalating Technology Education teacher shortages, which is now a grave problem in the profession (Householder, 1993; Litowitz, 1998; Vaglia, 1997; Volk, 1993, 1997, 2002; Weston, 1997). The total number of baccalaureate degrees granted to those preparing to teach in the field declined from 6,368 in 1970 (Volk, 2002) to an estimate of about only 800 in 2004. Hoepfl (1994) interviewed faculty from 20 discontinued technology teacher education programs, and found low enrollments to be a contributing factor in 19 of those 20 program closings. Householder (1993) identified 139 'operating' technology teacher education programs; compared to the finding of 70 active technology teacher education programs reported earlier in this chapter. Throughout the past decade, Technology Education has been formally designated a 'critical teaching shortage area' in states throughout the US. The longstanding nationwide shortage of licensed Technology Education teachers is a critical problem for the profession.

Based on the data reported earlier in this chapter, if the attrition rate (roughly the national average for all teachers in the US in 2004) is assumed as 8% among the estimated 36,000 Technology Education teachers currently employed in the US, there would have been a need for an estimated 2,880 newly licensed Technology Education teachers in fall 2004. This demand is approximately 3.5 times higher than the estimated 802 technology teacher education baccalaureate degrees awarded in 2004! If it was assumed that all of the 2004 Technology Education graduates accepted Technology Education teaching positions upon graduation, (a wildly optimistic assumption), the total number of 2004 technology teacher education graduates would have filled just over one fourth of the estimated 2880 Technology Education position openings that year. No national data' are available for the percentage of current Technology Education teachers in the US who are hired temporarily without a license—often with little or no professional coursework in Technology Education—but these estimates suggest that figure is likely to be high.

The Diversity Dilemma

Technology teacher educators have been predominantly Caucasian males. The current number of female Technology teacher educators in the US may be counted on one hand and all minority populations are underrepresented in the technology teacher education faculty ranks. This is a very serious problem for a field whose slogan is "technological literacy for all." The lack of diversity in technology teacher education has received considerable attention in the literature over the past two decades, including:

- the 1998 CTTE Yearbook, *Diversity in Technology Education* (Rider, 1998);
- publications resulting from the "Women's [TE] Leadership Symposium" in 1996; and
- a number of journal articles addressing diversity (for example, Erekson and Trautman 1995; Liedtke, 1986; Liedtke, 1995; Markert, 2003; O'Riley, 1996; Rider, 1991; and Zuga, 1996).

In light of the current goals in the profession, the shortage of under-represented populations in technology teacher education in the US should be deemed more serious today than ever before.

Engineering Education

The transition from IA to Technology Education in the 1980s was accompanied by growing interest in the 'design and technology' approach that evolved in the United Kingdom. By the end of the 20th century, the "technological problem solving method" (Savage and Sterry, 1990) had become a popular instructional approach in Technology Education programs across the US (Sanders, 2001). In the early 1990s, federal and state governments began to fund the development of Technology Education curriculum materials and in-service activities that facilitated integrated instruction in technology, science, and mathematics (see, for example, LaPorte and Sanders, 1995). Arguably, the use of the principles and processes of mathematics, science, and technology to solve technological problems is, in essence, "engineering." As early as 1992, the state of Virginia published course curriculum guides titled *Introduction to Engineering* and *Advanced Engineering.* In other words, Technology Education has been engaging with developmentally appropriate engineering content for more than a decade.

Few in the profession seemed to take notice when Bensen & Bensen (1993) suggested Technology Education embrace engineering content, nomenclature, and curricular organizers. But a great deal has changed since then. In the mid 1990s, the National Science Foundation (NSF) began funding engineering associations and faculty to develop educational materials and initiatives. In 1997, Project Lead the Way (PLTW) partnered with the College of Engineering at Rochester Institute of Technology to develop what is now a series of seven middle/high school pre-engineering courses. Currently that initiative utilizes about twenty university engineering programs to certify PLTW teachers who, in turn, offer PLTW courses in about a thousand schools across the US (Blais, 2004). Massachusetts has developed integrated science, engineering and technology standards, resulting in the *Massachusetts Science and Technology/Engineering Curriculum Framework* (2001). Since 2002, the NSF has supported about fifty 'Bridges for Engineering/Education' projects that brought the engineering and education faculties together at universities throughout the US. The National Academy of Engineering aggressively promoted a K–12 engineering education agenda in *Technically Speaking: Why All Americans Should Know More About Technology* (Pearson and Young, 2002). In 2003, the American Society for Engineering Education (ASEE) began a "K–12 and Pre-College Division" to promote K–12 engineering education activities. In fall 2004, PLTW invited 15 teacher education programs to partner with them and begin to provide pre-service PLTW certification. Also in 2004, the NSF funded a *National Center for Engineering and Technology Education,* with goals that included increasing the professoriate and recruiting under-represented populations to Technology Education.

In the midst of this unprecedented flurry of activity from the engineering and Technology Education communities, "engineering education" surfaced in 2004 as the hottest topic in TTE, as evidenced, for example, by the discussions that began to appear on the ITEA and CTTE Listservs and the Fall 2004 agendas at the Mississippi Valley and Southeast Technology Education Conferences. The role of engineering content in Technology Education and technology teacher education is likely to remain a principal educational issue in the years ahead.

AN EXAMPLE: THE COLLEGE OF NEW JERSEY

The technology teacher education program at the College of New Jersey (TCNJ) is a good example of a technology teacher education program that has moved forward with its curriculum. TCNJ is a medium-sized program situated in a state-supported institution with a history of preparing Industrial Arts/Technology Education teachers. The structure of the TCNJ's technology teacher education program is consistent with the Traditional Four-Year Model described earlier. The College's technology teacher education program sits in the Department of Technological Studies, which is housed in the School of Engineering. The program currently has five full-time and two affiliated faculty staff who are teaching 115 technology teacher education majors: 60 are enrolled in Technology Education and 55 in the new Math/Science/Technology—Elementary and Early Childhood Education option. Students in this option specialize in one of the five disciplines and may earn licensure in Technology Education through the middle school level.

TCNJ's technology teacher education program was arguably the first in the US to feature a design and technology approach. The "Center for Design and Technology," established there in the early 1990s, provided a home for their two affiliated faculties and *TIES Magazine,* one of the goals of which was "to foster design-based problem-solving" (Anderson, 1988). This Center received funding for several large curriculum development grants that featured the D&T approach, including *Project UpDATE* (Todd, 1997) and *Children Designing and Engineering* (Hutchinson, 2002). Two of their faculty co-authored *Design and Problem Solving in Technology* (Hutchinson & Karsnitz, 1994), arguably the first Technology Education text in the US emphasizing a D&T approach. Currently, they are working to enhance the pre-engineering focus of their program as well (Karsnitz, personal communication, October 1, 2004). Their attention to design instruction (emphasized in STL) and new engineering content is consistent with what appear to be two important new directions for technology teacher education in the US.

TCNJ's technology teacher education program, like many in the US, includes a core of general education courses, pedagogy/professional education classes and a broad range of technical courses consistent with the aforementioned trends, current professional literature, the *STL,* and technology teacher education accreditation standards. The four-year course sequence is shown in Table 1.

TEACHER CERTIFICATION

Teacher appointments were a local matter in the US until the middle of the 19th century, when states began to develop normal schools (teacher education programs) and provide funding for public elementary and secondary education. The need for greater accountability of state spending on education led to the development of State Boards of Education. Since the 1920s, the conventional way to earn a teaching license[3] in the United States

[3] Some states refer to these as teaching "certificates."

Table 1
Department of Technological Studies, 4-year Course Sequence

Fall		Spring	
Year 1			
Course	**Component**	**Course**	**Component**
First Year Seminar	Gen Ed	Academic Writing	Gen Ed
TST 161 Creative Design	Technical	LL Math/Science	Gen Ed
TST 171 Fundamentals of Technology	Technical	TST 111 Engineering Graphics	Technical
LL Math/Science	Gen Ed	TST 181 Structures & Mechanisms	Technical
		TST 191 Materials Laboratory	Technical
Year 2			
Course	**Component**	**Course**	**Component**
LL SPE 203 Psy. Dev. child/Adol.	Gen Ed	LL Arts/Humanities	Gen Ed
TED 280 Introduction to Teaching	Prof Ed	LL Math/Science	Gen Ed
TST 281 Designing with Materials	Technical	TST 261 2D-Design	Technical
TST 231 Electronic Control	Technical	TST 291 Control Laboratory	Technical
Year 3			
Course	**Component**	**Course**	**Component**
LL History (Technology in US)	Gen Ed	M/S Elective	Gen Ed
SPE 322 Inclusive Practices	Prof Ed	TED 380 JPE (280)	Prof Ed
TST 341 Biotechnical Systems	Technical	TED 460 Integrated MST for Learners	Prof Ed
TST 351 Robotics	Technical	TST 361 3-D Design	Technical
		TST 381 Prototyping Laboratory	Technical
Year 4			
Course	**Component**	**Course**	**Component**
TED 480 Content & Methods	PE	LL Arts/ Humanities	Gen Ed
TED 481 Seminar	Prof Ed	TED 492 Facilities Design & Mgmt.	Technical
TED 490 Student Teaching	Prof Ed	TST 431 Designing Production Sys.	Technical
		TST 495 Senior Design	Technical

was by graduating from a 'state approved program' (Darling-Hammond, 1999, p. 238) that met criteria established and monitored by state boards of education. Students graduating from such programs are thus assured of meeting the course and clinical experience requirements established by the state for initial teaching licensure. Currently, nearly all states utilize the state-approved program model. In addition, most states require teacher licensure candidates to pass one or more state or nationally developed/administered exams that assess professional and subject area knowledge.

Historically, state boards of education have regularly reviewed technology teacher education programs (for example, every 5 years) in order to sanction their 'approved program' status. Licensed teachers are required to take coursework and/or participate in professional in-service experiences in order to maintain their teaching license. States enter into 'reciprocity agreements' that allow teachers to be licensed immediately or with relative ease when moving from the state in which they earned their license to another state. For example, Virginia currently has reciprocity agreements with 48 other states.

Until the 1980s, teacher licensure regulations had been formulated independently by each of the 50 states, resulting in substantial variations from one state to another. Educational reform reports such as *A Nation Prepared: Teachers for the 21st Century* (Carnegie Forum on Education and the Economy, 1986) led to a general consensus of what all teachers should know and be able to do (Yinger, 1999). The Interstate Teacher Assessment and Support Consortium (INTASC) was formed to encourage cooperation/collaboration among states interested in rethinking teacher licensure standards. In the 1990s, the National Council for Accreditation of Teacher Education (NCATE) increased efforts to partner with states and professional associations in developing teacher education accreditation standards.

By the mid-1990s, there was a "remarkable consensus" on the ideals and standards for teacher licensure, accreditation, and certification (Yinger, 1999, p. 98). By the end of the century, NCATE had established partnerships with 45 states and the District of Columbia to "conduct joint reviews of colleges of education" (NCATE, 2000). In 1986, the ITEA and its affiliated Council on Technology Teacher Education (CTTE) voted to become an NCATE "Specialized Professional Association," on the speculation that NCATE affiliation would enhance the stature of the profession and assist the field in transitioning from IA to TE. Accordingly, the CTTE Accreditation Committee drafted the first ITEA/CTTE/NCATE technology teacher education Accreditation Standards, which took effect in 1987. The committee prepares revisions to these guidelines every five years, which are reviewed and approved by NCATE before going into effect. Significant changes were made in the 2004 revision of these accreditation standards to align them with STL. To date, about half of the active technology teacher education programs in the US have been through the NCATE accreditation process (CTTE, 2004). Through this evolving accreditation process, technology teacher education programs are probably becoming more alike from state to state than ever before, though substantial differences still remain.

SUMMARY

As with most educational decision-making in America, the future of technology teacher education rests individually with the fifty states. There are a number of critical issues and trends impacting technology teacher education in the US. Perhaps the most pressing is the pattern of declining enrollment that has plagued the field over the past three decades. This alarming technology teacher education enrolment decline—during a time when the children of the baby boom generation have been navigating post-secondary education in unprecedented numbers—has led to the downsizing of technology teacher education faculties and programs, a transition from the traditional technology teacher education model to the split-faculty technology teacher education model that requires fewer Technology teacher educators, and new “alternative” pathways to teaching licensure. The resulting Technology Education teacher shortages have led to “emergency hiring” in secondary Technology Education programs, in which unlicensed personnel are employed temporarily for up to three years. In many cases, secondary schools have downsized or closed their Technology Education programs. Over the past two decades, these practices have weakened the secondary and post-secondary Technology Education infrastructure in very significant ways.

While state licensure boards have approved alternative licensure pathways, standards for post-secondary teacher education have, paradoxically, become increasingly rigorous over the past two decades. Many believe this practice is undermining post-secondary teacher education, and ultimately, the overall quality of elementary and secondary education, as states and local divisions hire what some believe to be less qualified individuals to offset critical teacher shortages. The federal government has countered with the "No Child Left Behind Act," (NCLB) in an attempt to legislate "highly-qualified teachers" for public school classrooms. The NCLB Act threatens elective subjects such as TE, as it attempts to mandate new performance standards in the "academic" subject areas, which in turn will likely draw already limited resources away from Technology Education and other elective subjects.

Another trend is the serious decline in the number of doctoral granting institutions in the field from roughly a dozen such programs a decade ago to about half that number today. Teacher education has been under fire in the land-grant/research-centric institutions that once provided a steady stream of doctoral graduates to the profession. The now prevalent split-faculty technology teacher education model requires only about one third as many technology teacher education faculty staff as did the once-ubiquitous traditional technology teacher education model, resulting in a far smaller number of active Technology teacher educators in the US now compared with just several decades ago. In other words, the technology teacher education infrastructure has been vastly eroded over the past quarter century.

Meanwhile, Technology teacher educators across the US are dutifully working to address the curricular shifts motivated by the *STL* (ITEA, 2000), which are reflected in the recently updated ITEA/CTTE/NCATE accreditation standards. The very recent and considerable interest in increasing engineering content in the K–12 curriculum from both the Technology Education and engineering communities has caused technology teacher education to begin moving in that direction.

With the status of teacher education determined individually by each of the 50 states, technology teacher education is subject to influence from all of the aforementioned trends in different ways and degrees across the US. The politics of teacher licensure, teacher education program accreditation, teacher shortages, state and national standards, educational accountability, technological literacy, and the nature of alliances with potential allies, including engineering and science education, will conspire to shape the future of technology teacher education in the US in the decades ahead.

REFERENCES

Anderson, S. (1988, October). Letter to technology educators. *TIES Magazine.*

Battle, E. D. (1899). Manual training as related to girls. *Dissertation Abstracts International, 146*(67). (UMI No. AAG7233470)

Bensen, M. J. & Bensen, T. (1993). Gaining support for the study of *Technology. The Technology Teacher, 52*(6), 3–5, 21.

Blais, R. (2004, September). Presentation at the Project Lead the Way Meeting for Selected Technology Teacher Educators. Albany, NY, September 7, 2004.

Bonser, F. G. & Mossman, L. C. (1923). *Industrial arts for elementary schools.* New York: Macmillan.

Carnegie Forum on Education and the Economy. (1986). *A nation prepared: Teachers for the 21st century.* New York: Carnegie Council.

Council on Technology Teacher Education (2004). *ITEA/CTTE/NCATE accreditation standards.* Available: http://TechEd.vt.edu/CTTE/html/NCATE1.html.

Custer R. L. & Wright, R. T. (Eds.). (2002). Restructuring the Technology Teacher Education curriculum. in Ritz, Dugger, & Israel CTTE Yearbook #51. *Standards for Technological Literacy: The role of teacher education.* Peoria, IL: Glencoe/McGraw-Hill.

Darling-Hammond, L. (1999). Educating teachers for the next century: Rethinking practice & policy. In Griffin, G. A. (Ed.). *The education of teachers: Ninety-eighth yearbook of the National Society for the Study of Education.* Chicago: University of Chicago Press. pp. 221–256.

Dugger, W. E., Miller, C. D., Bame, E. A. Pinder, C. A., Giles, M. B., Young, L. H., & Dixon, J. D. (1980). *Report of the Survey Data.* Blacksburg, VA: Virginia Polytechnic Institute and State University.

Educational Testing Service (2004). The Praxis series: Professional assessments for beginning teachers. Available http://www.ets.org/praxis/

Erekson, T. L. & Trautman, D. K. (1995). Diversity or conformity? *Journal of Industrial Teacher Education, 32*(4), 32–42.

Gerbracht, C. & Babcock, R. (1969). *Elementary school industrial arts.* New York: Bruce.

Hoepfl, M. C. (1994). Closure of technology teacher education programs: Factors influencing discontinuance decisions. Doctoral dissertation, West Virginia University, 1994). *Dissertation Abstracts International, 55–06A,* 1535.

Householder, D. L. (1993). Technology teacher education: Status and prospect. *Journal of Technology Studies XIX* (1), 14–19.

Hutchinson, J. & Karsnitz, J. R. (1994). *Design and problem solving in technology education.* Albany, NY: Delmar Publishers, Inc.

Hutchinson, P. (2002). Children Designing & Engineering: Contextual learning units in primary design and technology. *Journal of Industrial Teacher Education, 39*(3), 122–145.

Industrial Arts Teacher Education at Oswego to 1941. (2004). Available: http://www.oswego.edu/tech/history.html. No Author.

International Technology Education Association. (1996). *Technology for All Americans: A Rationale and Structure for the Study of Technology.* Reston, VA: Author.

International Technology Education Association. (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

Karsnitz, J. (2004). Personal communication, October 1, 2004.

LaPorte, J. & Sanders, M. (1995). Technology, science, mathematics integration. In E. Martin (Ed.), *Foundations of technology education: Yearbook #44 of the council on technology teacher education.* Peoria, IL: Glencoe/McGraw-Hill.

Lewis, T. (1996). Accommodating border crossings. *Journal of Industrial Teacher Education 33*(2), 7–28.

Liedtke, J. (1986). Mentors and role models: Influences on the professional career. *The Journal of Epsilon Pi Tau 12*(1), 41–44.

Liedtke, J. (1995) Changing the organizational culture of technology education to attract minorities and women. *The Technology Teacher, 51*(6), 9–14.

Litowitz, L. S. & Sanders, M. E. (1999). *Alternative licensure models for technology education: Monograph #16 of the Council on Technology Teacher Education.* Reston, VA: Council on Technology Teacher Education.

Litowitz, L. S. (1998). Technology ed. teacher demand and alternative route licensure. *The Technology Teacher 57*(5), 23–28.

Markert, L. R. (2003). And the beat goes on: Diversity reconsidered. G. Martin & H. Middleton (Eds.). *Initiatives in technology education: Comparative perspectives.* Technical Foundation of America and the Centre for Technology Education Research, Griffith University.

Miller, W. R. & Boyd, G. (1970). *Teaching elementary industrial arts.* South Holland, IL: Goodheart-Willcox Company, Inc.

O'Riley, P. (1996). A different storytelling of technology education curriculum re-visions: A storytelling of difference. *Journal of Technology Education, 7*(2), 28–40.

Pearson, G. & Young, A. T. (2002). *Technically speaking.* Washington, DC: National Academy Press.

Rider, B. L. (1991). Problems and issues facing women in technology education. Paper presented at the Mississippi Valley Industrial Teacher Education Conference, Nashville, TN.

Rider, B. L. (Ed). (1998). *Diversity in Technology Education.* CTTE Yearbook #47. Peoria, IL: Glencoe/McGraw-Hill.

Sanders, M. E. (2001). New paradigm or old wine: The status of technology education practice in the US. *Journal of Technology Education, 12*(2), 35–55.

Sanders, M. E. (2003). The perplexing relationship between Technology education and career & technical education in the US. In G. Martin & H. Middleton (Eds.), *Initiatives in Technology Education: Comparative Perspectives.* San Marcos, TX: Technical Foundation of America.

Savage, E. & Sterry, L. (Eds.). (1990). *A conceptual framework for technology education.* Reston, VA: International Technology Education Association.

Schmidt, K. and Custer, R. L. (Eds.) (2004). *Industrial teacher education directory.* Reston, VA: Council on Technology Teacher Education.

Schmitt, M. L. & Pelley, A. L. (1966). Industrial arts education: A survey of programs, teachers, students, and curriculum. U. S. Department of Health, Education, and Welfare,. OE 33038, Circular No. 791. Washington, DC: Office of U.S. Government Printing Office.

Steeb, R. V. (1976, March). Funding industrial arts programs at the state level. *Man/Society/Technology,* 171–172.

Todd , R. (1997). A new paradigm for schooling. In J.J. Kirkwood & P. N. Foster (Eds.), *Elementary school technology education.* New York: Glencoe/ McGraw Hill.

Warner, W. E., Gary, J.E., Gerbracht, C. J., Gilbert, H. G., Lisack, J. P. Kleintjes, P. L., & Phillips, K. (1947, April). *A Curriculum to Reflect Technology.* Paper presented at the annual conference of the American Industrial Arts Association.

Vaglia, J. (1997, October). *Technology education majors in colleges of the southeast: An enrollment overview.* Paper presented at the annual conference of the Southeast Technology Education Association, Roanoke, Virginia.

Volk, K. S. (1993). Enrollment trends in industrial arts/technology teacher education from 1970–1990. *Journal of Technology Education, (4)*2, 46–59.

Volk, K. S. (1997). Going, going, gone? Recent trends in technology teacher education programs. *Journal of Technology Education, (8)*2, 67–71.

Volk, K. S. (2002). *Enrollment trends in technology teacher education.* Paper presented at the Annual Conference of the International Technology Education Association, 3/15/02, Columbus, OH.

Weston, S. (1997). Teacher Shortage: Supply and demand. *The Technology Teacher, 57*(1), 6–9.

Winslow, L. L. (1922). *Elementary industrial arts.* NY: The Macmillan Company.

Yinger, R. J. (1999). The role of standards in teacher education. In Griffin, G. A. (Ed.). *The education of teachers: Ninety-eighth yearbook of the National Society for the Study of Education.* Chicago: University of Chicago Press.

Zuga, K. F. (1996, October). Women's ways of knowing and technology education. Paper presented at the Women's Leadership Symposium, Chicago.

Zuga, K. F. (1997, March 22). Technology education teacher education. Paper presented at the International Technology Education Conference in Tampa, FL.

Professional Growth

Section X

STANDARD 10—PROFESSIONAL GROWTH
Technology teacher education program candidates understand and value the importance of engaging in comprehensive and sustained professional growth to improve the teaching of technology.
Indicators:
The following knowledge, performance, and disposition indicators provide guidance to better understand the scope of Standard 10. The program prepares technology teacher education candidates who can:
Knowledge Indicators:
• Demonstrate a continuously updated and informed knowledge base about the processes of technology. • Continuously build upon effective instructional practices that promote technological literacy.
Performance Indicators:
• Apply various marketing principles and concepts to promote technology education and the study of technology. • Collaborate with other candidates and professional colleagues to promote professional growth and professional development activities. • Become actively involved in professional organizations and attend professional development activities to become better prepared to teach technology education. • Develop a professional development plan for self-improvement in curriculum and instruction in technology education.
Disposition Indicators:
• Value continuous professional growth through involvement in a variety of professional development activities. • Demonstrate the importance of professionalism by promoting technology organizations for students in the technology classroom. • Reflect upon their teaching to improve and enhance student learning.

Professional Associations, Organizations, & Other Growth Opportunities

Chapter 15

Edward M. Reeve
Utah State University
48th CTTE Yearbook, 1999

"The opportunity to participate actively in the development of one's profession, not to mention one's civic responsibilities, is a rare privilege" (*Let George Do It,* 1942, p. 2). These words were echoed by the editor of the first issue of *The Industrial Arts Teacher* (now *The Technology Teacher*) and still hold true today. Joining a professional association or organization is indeed a privilege. For those who join, it provides them numerous opportunities to grow both personally and professionally by participating in many of the formal and informal activities sponsored by the association or organization.

Organizations and associations bring together groups of people with common backgrounds and interests. In most instances, the organization is a well-structured unit. It consists of various subgroups (e.g., committees) and sponsored activities (e.g., annual conferences) that help contribute to the goals and purposes of the organization.

The purpose of this chapter is to examine a variety of professional associations, organizations, and other growth opportunities for those in the field of technology education. This chapter describes the roles of associations and organizations in relation to personal professional development and illustrates a variety of opportunities for those in the field of technology education.

THE ROLE OF ASSOCIATIONS AND ORGANIZATIONS IN PERSONAL AND PROFESSIONAL DEVELOPMENT

Becoming a member in a professional association or organization offers the member many benefits. It exposes them to the latest trends in their field. It provides a forum where they can discuss ideas with other members and provides ample professional growth opportunities where members can become involved in the decision-making process of the entire organization. Members who participate in professional organizations soon learn that they do indeed have a "voice" that can be heard and can be used to change or alter the organization in important ways.

Professional organizations offer members an opportunity for professional growth through the sharing of ideas. It offers them exposure to the latest trends and developments in their field. Organizational publications, national and regional conferences, and workshops help to keep members on the "cutting edge" in their field. Many organizations offer their members a monthly magazine and may also publish a scholarly journal that discusses current research efforts in their field. Other publications may include books, newsletters, recruitment materials, audio and videotapes, and special publications that feature information on timely issues or trends that are impacting the organization.

A recent development for many organizations is the creation of an Internet Web site. Numerous organizations have developed Web sites to keep their members informed of current developments. These Web sites can provide members with a wealth of information about the organization, its mission and history, members of the executive board, upcoming conferences, and scholarship and award programs. In addition, the Web site may provide links to sites and offer a career placement service.

The annual conference is the highlight of most organizations. The conference brings together a large gathering of members where they are exposed to the latest trends, developments, and products that are influencing the field. At the conference, members have opportunities to formally or informally express their ideas or thoughts. Formally, members can submit a proposal to speak at the conference. If the proposal is accepted, they can share their ideas on a variety of topics. These may range from new technological developments that are impacting the field, to a philosophical presentation on where they feel the profession is headed. At most conferences, there are many formal and informal social activities (e.g., banquets, alumni dinners, parties, etc.) that occur. These gatherings provide members with an opportunity to interact personally and network with colleagues. They allow new members to meet the "leaders" of the field or find information on how to become involved in the organization.

Organizations work for the good of its members and recognize those who achieve. Many become involved in government relations where they stay in contact with government agencies, elected officials, and other agencies that may influence or affect the organization. Organizations take great pride in honoring their members. Many have award programs where they recognize outstanding individuals or programs. Organizations may also provide its members with opportunities for growth through scholarships and grants, where eligible members receive monetary awards.

JOINING AND ENCOURAGING OTHERS TO JOIN A PROFESSIONAL ASSOCIATION OR ORGANIZATION

All professionals share one common element—involvement in their association or organization. Becoming involved professionally means joining a professional association. There are many good reasons for becoming a member of a professional association. Hanson (1983) identified the following:

1. There is strength in numbers. More political power can be realized when a large percentage of practicing professionals belong to professional associations.
2. Initiatives that are established by the association have better opportunity to be realized when the membership speaks with unity.
3. Associations provide a common link for professional discourse.
4. Professionalism is itself spawned out of active, purposeful activity as it is practiced by its members and observed by prospective or less dedicated members.
5. Association-sponsored gatherings, such as conferences, provide members with a forum for the exchange of knowledge and methods or approaches to carry out initiatives through informal conversations and scheduled speeches as well as refereed periodicals and educational materials.
6. Practicing professionals can become personally acquainted with professional leaders and subsequently may question and discuss reported professional positions. (p. 206)

Joining a professional organization should occur early in one's career. Initial exposure to professional organizations typically occurs during one's undergraduate preparation. For example, in technology teacher education professional methods courses, students learn about the associations and organizations affiliated with their field. As a first step in becoming a professional, they are encouraged to join, often at a discounted student rate.

As a professional in an organization, it is your responsibility to encourage others to join. However, prospective new members to a profession often ask, “Why should I join the organization?” They want to know what benefits they will receive. They want to know where their money from dues is going and how joining a professional organization will help them. As a member in the professional organization, it is your duty to help answer these questions.

Encouraging others to join an organization can begin with your own personal reflections. Sharing with prospective members how the organization has personally helped you is one of the best recruitment methods. Your discussions should include how the organization has made you a better professional by allowing you to become involved in the profession; keeping you informed of current technological innovations; providing you with meaningful activities; and giving you opportunities to discuss current issues and trends with other professionals.

When you join an association, you are indicating your desire to work for the good of the association. It is a commitment you make. It shows that you care about your profession and your chosen career. It demonstrates a willingness to become involved and support the causes you believe in. It also means becoming pro-active. An association cannot operate without the support and commitment of its members. Being a member of a professional organization means more than just receiving a monthly journal or newsletter. It means contributing to the association through the sharing of your own work and willingness to participate in association activities and committees.

PROFESSIONAL ASSOCIATIONS AND ORGANIZATIONS IN TECHNOLOGY EDUCATION

Professional organizations and associations in education are formed to support, promote, and advance a field or discipline. They are guided by such components as a strategic plan, a mission, and goal statements that the organization has formulated. Organizations are dynamic entities in a state of continual change. New directions, new members, and new technology may change the way the organization operates. However, most organizations and associations contain the following common elements:

- Board of Directors: functions to oversee the entire organization. Typical members may include an executive director, president, president-elect, treasurer, secretary, and representatives from each of the organization's councils, divisions, or regions.
- Publications: includes such items as journals, yearbooks, and special publications.
- Committees: serve to promote and advance the organization. Examples of committees include executive, conference planning, membership, research, and awards.
- Conferences and Workshops: annual and regional.
- Internet Web Site: now common for many organizations.

There are many professional associations, organizations, and affiliated councils for those in the field of technology education. They offer a variety of growth opportunities for those members who participate. As the field of industrial arts changed to technology education, so did the names of most of the councils and associations affiliated with industrial arts. Beginning in the 1980s, most associations and councils changed their names to reflect technology education. For example, in 1985 the American Industrial Arts Association (AIAA) changed its name to the International Technology Education Association (ITEA) (Reeve, 1990). This section will present an in-depth review of the ITEA showing the makeup and functions of a typical association and its affiliated councils, and a brief review of other professional associations for those in the field of technology education.

THE INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

The International Technology Education was formed in 1939 as the American Industrial Arts Association (AIAA). The association was organized during the annual conference of the American Association of School Administrators in Cleveland, Ohio. The first conference was sponsored by Epsilon Pi Tau (EPT) as a part of the fraternity's tenth anniversary celebration. Approximately 20 leaders in the field of industrial arts met to discuss how to deal with many of the problems created by the national growth in industrial arts (Barlow, 1967, pp. 83-85).

Today, the ITEA is the leading association for professionals in the field of technology education. It is an association whose major purpose is to promote the advancement of technology education in schools. Starkweather (1995) offers an excellent in-depth review of the International Technology Education Association in the Council on Technology Teacher Education (CTTE) 44th Yearbook: Foundations of Technology Education. In Chapter 17 of the yearbook he reviews the ITEA's organizational structure, its culture, its vision, and mission. He also reviews its major functions, association subgroups, the Technology Education Advisory Council (TEAC), and the Foundation for Technology Education (FTE).

The ITEA board of directors oversees the operation of the association. The board meets periodically to discuss and direct the goals of the entire organization. Members of the board include: the executive director, the president, past president, president-elect, representatives from each of the ITEA's four regions, and the directors from each of the councils (i.e., CTTE, TECA, and TECC) affiliated with the ITEA. Membership is open to anyone interested in supporting and promoting technology education. Individual memberships are available in the following categories: professional, undergraduate (TECA/ITEA), retired, and sustaining technical representatives. The ITEA also offers group memberships to elementary schools, institutional/universities, and sustaining companies (ITEA, 1997).

The ITEA offers its members numerous benefits and services. *The Technology Teacher,* published eight times a year, keeps its members abreast of current issues and trends affecting the field of technology education. Its timely articles and feature stories provide members with practical teaching information, learning activities, new curriculum developments, and reviews of top programs. The journal is a refereed publication. The editorial review board is made up of a chairperson and other ITEA professionals who are responsible for reviewing manuscripts submitted to the journal. Another important publication sponsored by both the ITEA and the Council of Technology Teacher Education (CTTE) is the *Journal of Technology Education* (JTE). This refereed research journal, available on-line at http://scholar.lib.vt.edu/ejournals/JTE/, provides members with the latest developments and trends in technology education. The journal focuses on technology education research efforts, philosophy, theory, and practice. Also, included in the journal are book reviews, editorials, guest articles, and research digests.

The ITEA also provides its members with many other publications. These publications are related to all aspects of technology education, from current research to advocacy issues. An excellent example of a document disseminated by the ITEA was the 1996 Technology for all Americans, A Rationale and Structure for the Study of Technology. Other ITEA publications include the Curriculum Briefs developed to meet the needs of classroom teachers and Technology and Children, a periodical for those teaching technology in grades K-6.

The annual ITEA conference and trade show is a highlight of the association. It is a time for members from all around the world to meet and grow both personally and professionally. General and special interest sessions allow members to keep current on their interests. Formal and informal activities allow members to network. Recognition and scholarship ceremonies honor those who have achieved excellence in the field. The trade show features the latest innovations and products from vendors.

The ITEA provides its members with many additional services. A very impressive Internet web page available at http://www.iteawww.org has been developed by the ITEA. Their home page contains a wealth of information related to technology education and the ITEA association. For example, on this page one can search to find out the facts about the ITEA; review awards, grants, and scholarships offered by the ITEA; learn about related technology education organizations and universities; keep informed about the annual ITEA conference; visit the software bank; or use the placement service. Other services provided by the ITEA to its members include a variety of insurance programs and discounted travel services (ITEA, 1997).

Members of the organization can take advantage of its impressive grants, scholarship, and fellowship opportunities that are sponsored by the ITEA, corporations, other associations, and the Foundation of Technology Education (FTE). As Starkweather (1995) noted:

> 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. (p. 564)

The ITEA also annually recognizes outstanding people for excellence in the field. Teacher and Program Excellence Awards honor outstanding teachers and programs. Other awards given by the profession include the Academy of Fellows, Award of Distinction, Prakken Professional Cooperation Award, Lockette Humanitarian Award, Distinguished EEA-SHIP Member Award, Special Recognition Award, and Meritorious Service Award. The association also has a Distinguished Technology Educator (DTE) recognition program to honor the leaders in the profession (ITEA, no date).

Associations and organizations cannot function without the support and commitment from its members. Most associations provide members with a variety of support committees that are formed to meet the needs identified by the association. The ITEA has a variety of committees that allow members to "get involved" and support the goals of the association. Most ITEA committees meet at the annual conference to discuss the goals and tasks required of the committee, develop an action plan, and to report on the committee's progress. The following are current ITEA committees: Affiliations, Awards, Ballot Counting, Conference Program, Elections, Government Relations, Liaison, Membership, Resolutions, Special Events, DTE Review Board, JTE Review Board, Publications Review Board, and the TTT Review Board.

Associations and organizations need support from within. This support typically comes in the form of professional affiliated councils. These affiliated councils composed of special interest groups work to advance their own interests and those of the affiliated organization. Within the ITEA association, three major support councils have been formed. To become a member of any of these councils, the individual must also be a member of the ITEA. A brief review of these councils and associations will be presented here. Lauda (1995) in Chapter 18 of CTTE's 44th Yearbook presents an in-depth review of professional councils associated with the ITEA: *Foundations of Technology Education.*

COUNCIL ON TECHNOLOGY TEACHER EDUCATION

Founded in 1950, the Council on Technology Teacher Education (CTTE) (http://teched.vt.edu/ctte/) provides leadership to college/university professionals who are involved in technology teacher education. The goals of the council are as follows (CTTE, 1997):

- Support and further the professional ideals of technology teacher education.
- Define the purposes and achieve the professional goals of technology teacher education.
- Stimulate research and the dissemination of information of professional interests.
- Provide educational leadership opportunities to its membership.

The council offers its members a variety of activities and publications. At the annual ITEA conference, the council offers special interest sessions and meetings for its members. Also, at the conference, it recognizes outstanding leaders in technology teacher education and outstanding members of the council. The major publication of the CTTE is the CTTE Yearbook. Published annually since 1952, it focuses on current topics that hold promise for improving the quality of technology teacher education. The council also publishes timely monographs and newsletters to help members stay professionally current. In addition, the council and the National Association of Industrial and Technical Teacher Educators (NAITTE) annually publish *The Industrial Teacher Education Directory* that lists information about educators from more than 250 institutions of higher learning. Finally, the council in support with ITEA publishes *The Journal of Technology Education* (CTTE, 1997).

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION COUNCIL OF SUPERVISORS

Founded in 1951, the ITEA Council of Supervisors' (ITEA-CS, Web site http://www.seelb-eurotecnet.demon.co.uk/iteasc/).mission is to provide support and leadership for those who coordinate or supervise technology education programs. This association of professionals helps promote technology education through the development of relevant technology education curricula, the development and promotion of model technology education programs, and by offering teacher in-service programs. At the annual ITEA conference, the council offers special interest sessions and meetings for its members and recognizes those that have achieved excellence in the field. It publishes a variety of publications, including forum discussions, a newsletter, and information on supervision and administration (ITEA, 1997).

TECHNOLOGY EDUCATION FOR CHILDREN COUNCIL

Founded in 1962, the Technology Education for Children Council (TECC) mission is to promote technology education in the elementary school by supporting teachers with instructional materials and in-service workshops. At the annual ITEA conference, the council offers special interest sessions and meetings for its members. It publishes a newsletter, monographs, and develops curriculum activity packages (ITEA, 1997).

ASSOCIATION FOR CAREER AND TECHNICAL EDUCATION (ACTE) TECHNOLOGY EDUCATION DIVISION

Founded in 1926, the American Vocational Association (AVA) (now known as The Association for Career and Technical Education—ACTE)is the largest national education association dedicated to the advancement of vocational education. Its mission is to provide educational leadership in developing a competitive workforce. It is a professional organization of teachers, educational administrators, teacher educators, counselors, business and industry partners, students and others with an interest in workforce education. It carries out a diverse array of programs that advance vocational-technical and school-to-careers education (AVA, 1997).

The ACTE keeps an active Web site available at http://www.avaonline.org. Their Web site offers information on such items as conventions and workshops, legislation news, and new products available to members. All ACTE members receive the monthly journal *Techniques* which is a magazine that keeps members current on issues and trends affecting vocational education. In addition to an annual conference and pre-conference workshops, the ACTE also sponsors a variety of workshops during the year at various geographic locations. ACTE offers its members a wealth of publications and products designed to promote and improve vocational education.

The association's policy is determined by a 21-member elected Board of Directors, including a President, Past President, President-Elect, and 18 vice presidents representing the association's 13 divisions and five geographic regions. One of the association's divisions is the Technology Education Division (TED). The mission of the TED is to advance the development of technological literacy and capability for life and work. The goals of the technology education division are as follows (ACTE-TED, 1997):

1. Promote professional unity and collaboration.
2. Provide activities and products for leadership development and program improvement.
3. Increase the flow of new technology teachers into the profession.
4. Provide effective advocacy for the profession.
5. Strengthen the operation and resource base for the division.

Technology education division members meet at the annual ACTE conference to discuss current technology education issues and trends. Also, the division sponsors several special interest sessions during the conference. Those who are TED members must also be members of the ACTE.

NATIONAL ASSOCIATION OF INDUSTRIAL AND TECHNICAL TEACHER EDUCATORS

The National Association of Industrial and Technical Teacher Educators (NAITTE) was founded in 1937. The association's primary audiences are those who prepare teachers and instructors in the following fields: technology education, trade and industrial education, technical education, and industrial and military training. The association's primary goals are to promote opportunities for professional growth and development, and to develop a cooperation among related client groups (NAITTE, 1997).

The association offers its members a variety of activities and publications. At the annual ITEA and ACTE conferences, the association offers special interest sessions and meetings for its members. The association has a Web page available at http://www.orst.edu/Dept/NAITTE, where members can find out about activities and services provided by the association. The major publication sponsored by NAITTE is the highly respected *Journal of Industrial Teacher Education* (JITE). The journal is available online at http://borg.lib.edu/ejournals/JITE/jite.html, and it is published four times a year. The association publishes a variety of other professional publications.

Members in NAITTE have many committees on which to serve. Examples of NAITTE committees include the executive, program planning, auditing, nominating, membership, awards, and research. Ad-hoc NAITTE committees include the T&I Teacher Standards Committee, Electronic Communication/Internet Task Force, the NAITTE Foundation Task Force, and the Graduate Student Task Force. NAITTE gives its members various awards, including the prestigious Silvius-Wolansky Award that honors outstanding young industrial education faculty members.

TECHNOLOGY EDUCATION COLLEGIATE ASSOCIATION

Founded in 1972, the Technology Education Association (TECA) consists of undergraduate technology education students. The goal of the association is to motivate and involve future technology teachers in professional and leadership development activities. The association is organized into chapters at various universities and colleges around the country. TECA members must be ITEA members. To encourage members to join, the dues are one-half the cost of the professional ITEA member price. TECA members receive a newsletter and participate in a variety of local chapter activities and competitions. At the ITEA annual conference, and some regional conferences, the TECA holds meetings, socials, and competitions between other TECA chapters (ITEA, 1997).

STATE TECHNOLOGY EDUCATION ASSOCIATIONS AND ORGANIZATIONS

As previously reviewed, there are numerous organizations and associations at the national and international level that support the mission and goals of technology education. Just as important are the state associations formed to promote technology education within a state. These associations are formed to serve both students and teachers in technology education with their mission and goals mirroring those of the ITEA.

Almost all states have their own technology education association. Most associations are affiliated with the ITEA and are organized in a similar manner. The association will typically contain a governing body or executive committee to guide the association. This governing body may include an elected president, president-elect, past president, vice president, treasurer, and secretary. State associations also typically work closely with the state's technology education supervisor or specialist. The supervisor may assist the organization in the planning of a state conference, developing in-service workshops and as serving as a consultant to the association.

Membership in state associations is open to almost anyone interested in technology education. Members may include those teachers from K-12 schools, local college and university instructors, college students, administrators, as well as retired teachers. State technology education associations provide their members with many benefits and opportunities to serve the profession. Perhaps the most important benefit that is provided to members who join an association is the opportunity to become involved with their fellow colleagues. Collegiality is emphasized in state technology education associations. Members are encouraged to interact with their colleagues and to find out what others are doing in their programs (i.e., to find out what works and what doesn't). Members in a state association have the opportunity to discuss and share such items as curriculum, activities, programs, funding, grant opportunities, local graduate programs, and the purchasing of supplies and equipment.

Members who join state technology education associations receive many of the same benefits as provided by national associations. States associations hold an annual conference featuring nationally known speakers, workshops and special interest sessions that help members to stay current in their field. The conference is typically the most important function of the association. It provides an opportunity to network with other members, to examine new vendor products, and to honor outstanding programs and individuals who have served the profession and association. Many conferences also feature a "tech-fest" or "tech exposition" where both students and teachers can show off their best work.

State conferences are not exclusively for technology education teachers, many conferences encourage technology education students from K-12 and college/university schools to attend and participate. Students from these schools may participate in state contests or events. The Technology Student Association (TSA) may sponsor contests and events for K-12 students. The Technology Education College Association (TECA) may sponsor events for college/university students. In addition, some associations offer scholarships to outstanding secondary students who plan to pursue a career in technology education.

Members of state technology education associations are encouraged to become involved. There are numerous positions to fill in state associations. For those wanting to get involved in leadership positions, they may run for an executive position (e.g., president of the association). Most associations also have various committees which members can serve on or chair. Since most associations publish a newsletter or journal, members are needed on the publications committee. Other committees may include those for conference planning, legislative work, events, awards, scholarship and membership.

As previously mentioned, many associations periodically publish an association newsletter or journal. This publication may contain information on how to contact executive committee members, features on local programs or individuals within the state, stimulating classroom activities, and information on the annual conference. A recent trend among many state associations is the development of their own Internet Web site. Their home page may contain information about the association including: the executive committee, its mission and goals, a history of the association, links to other technology education schools within the state, their newsletter, related technology education links, and information about the state's annual conference.

State technology education associations provide the opportunity for many to become professionally involved in their chosen field. It gives them an opportunity to participate and make decisions on issues that may directly affect their careers or programs. Low dues and the closeness (i.e., within the state) of meetings, workshops and conferences make joining a state association very attractive.

LOCAL TECHNOLOGY EDUCATION ASSOCIATIONS AND ORGANIZATIONS

Local technology education associations and organizations typically exist to meet the needs of technology education professionals who live and work within a local area or region. For example, a large school district may have its own technology education association consisting of the district's technology education teachers. Local technology education associations are formed to promote and support technology education within a specified area or district. These associations provide opportunities for a small group of members to get together to share activities and ideas or visit other technology education programs. In addition, these associations may plan local contests or work together on public displays that spotlight the efforts of local technology education programs.

Members of the local association may hold scheduled or unscheduled meetings to discuss the mission and goals of the association. Members usually choose a leader of the group who is responsible for scheduling meetings, planning group functions, and forming support committees within the association. A major benefit of local associations is that it provides opportunities for technology education professionals to work closely with one another. Members of local associations are also usually members in the state's technology education association and participate in the association's sponsored activities.

OTHER PROFESSIONAL ASSOCIATIONS AND ORGANIZATIONS

There are literally thousands of other organizations and associations available to technology education professionals. These organizations and associations bring together individuals with similar interests who are willing to work together and to promote their common interests. Also, many organizations and associations try to work with other organizations and associations who share similar and common interests. For example, the ITEA works with many other groups. In his discussion on an association's culture and its relationships to other groups, Starkweather (1995) notes:

> 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 of Engineering Education, and the National Council for Teachers of Mathematics. Other relationships have been forged with curricular groups, such as the Association for Curriculum and Development, Phi Delta Kappa, and the Council for Basic Education. (pp. 549–550)

Professionals in technology education have a wide range of interests. Joining other organizations helps contribute to the individual's professional and personal growth. Individuals join other organizations for many reasons, including to strengthen their own backgrounds in the areas they teach (e.g., in manufacturing or communications) or to support other disciplines related to technology education.

As previously mentioned, organizations and associations have many common elements which may include an executive director of the organization, various publications, committees, conferences and workshops, and in many instances, an Internet Web page. Without exception, all organizations encourage their members to become actively involved. The purpose of this section is to briefly review some other organizations and associations that those in technology education may find interesting and helpful in contributing to their professional growth. Where appropriate, an Internet address is provided so that the reader can find out more information about the organization or association.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS)

The American Association for the Advancement of Science (http://aaas.org) is among the oldest societies in America, having been founded in Philadelphia in 1848. It is a nonprofit professional society dedicated to the advancement of scientific and technological excellence across all disciplines, and to the public's understanding of science and technology. The mission of the association is to further the work of scientists; facilitate cooperation among them; foster scientific freedom and responsibility; improve the effectiveness of science in the promotion of human welfare; advance education in science; and increase the public's understanding and appreciation of the promise of scientific methods in human progress. Members include scientists, engineers, science educators, policymakers, and others dedicated to scientific and technological progress. AAAS is affiliated with many other scientific and engineering organizations. The association publishes *Science Magazine* and other related science publications. It holds an annual meeting and provides it members with a variety of fellowships, grants, and prizes. The association's major science education reform effort is *Project 2061* (AAAS, 1997).

ASSOCIATION FOR SUPERVISION AND CURRICULUM DEVELOPMENT (ASCD)

The Association for Supervision and Curriculum Development (ASCD) (http://www.ascd.org) is a very large international, nonprofit, nonpartisan education association committed to the mission of forging covenants in teaching and learning for the success of all learners. Founded in 1943, ASCD provides professional development in curriculum and supervision; initiates and supports activities to provide educational equality for all students; and serves as a world-class leader in education information services. Members of ASCD includes superintendents, supervisors, principals, teachers, professors of education, school board members, students, and parents who share a commitment to quality education and a belief that all students can learn in a well-planned educational program. The association holds an annual conference and offers a variety of programs throughout the year. It produces a variety of publications including journals, newsletters, books, and audio and videotapes. Its regular publications include *Educational Leadership, The Journal of Curriculum and Supervision,* and *Education Update* (ASCD, 1997).

ASSOCIATION FOR EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY (AECT)

The mission of the Association for Educational Communications and Technology (http://aect.org) is to provide leadership in educational communications and technology by linking professionals holding a common interest in the use of educational technology and its application to the learning process. The association is dedicated to the improvement of instruction through the utilization of media and technology. It provides a forum for the exchange of information among professionals in educational technology: audio-visual media, library and microcomputer specialists; education administrators; researchers; teachers and professors; learning resource specialists; curriculum developers; television producers and directors; and a variety of other professionals who require expertise in instructional technology. The association holds annual conferences and regional workshops for its members. It produces a variety of publications including books, a newsletter, and videotapes. Its major publications include *TechTrends,* and the *Educational Technology Research and Development* journal, published quarterly (AECT, 1997).

AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE)

The American Society for Engineering Education (ASEE) (http://www.asee.org) founded in 1883, is a nonprofit organization dedicated to improving all aspects of engineering education. Its members represent every discipline of engineering and engineering technology. It includes faculty and academic administrators as well as industry and government representatives. Its mission is to promote engineering and engineering technology by promoting excellence in instruction, research, public service, and practice; exercising worldwide leadership; fostering the technological education of society; and providing quality products and services to members. Its major publications include, the magazine *PRISM,* and its scholarly professional journal, *The Journal of Engineering Education* (ASEE, 1997).

GRAPHIC ARTS TECHNICAL FOUNDATION (GATF)

The Graphic Arts Technical Foundation (GATF) (http://gatf.org) is a nonprofit, member-supported, and member-directed organization committed to research of the evolving print production processes and helping printers use new techniques effectively. It serves the graphic communications community as the leading source of technical information, education, and services about lithography and other printing processes. The organization is continually developing new products; technical, library, and environmental services; and training programs to meet the evolving needs of the graphic arts industry. Its bi-monthly magazine *GATFWorld* keeps members informed about new graphic arts technologies and trends. GATF is also responsible for administering the very popular National Scholarship Trust Fund (NSTF). The NSTF is a not-for-profit, private, industry-directed organization that dispenses undergraduate college scholarship and graduate fellowship assistance to talented men and women interested in graphic communication careers (GATF, 1997).

NATIONAL ASSOCIATION OF INDUSTRIAL TECHNOLOGY (NAIT)

The National Association of Industrial Technology (NAIT) (http://nait.org) was founded in 1967 as a nonprofit professional association dedicated to the improvement and expansion of Industrial Technology programs in institutions of higher education and the continuing professional development of graduates of these programs. NAIT holds an annual conference for its members and offers them a variety of publications, including the quarterly published *Journal of Industrial Technology.* The journal contains both refereed and non-refereed articles of general interest to the profession. Other NAIT publications include, an Accreditation Handbook, a Baccalaureate Program Directory, and Convention Proceedings (NAIT, 1997).

NATIONAL SCIENCE TEACHERS ASSOCIATION (NSTA)

Founded in 1944, the National Science Teachers Association (NSTA) (http://nsta.org) is the largest organization in the world committed to promoting excellence and innovation in the teaching of science. The Association serves as an advocate for science educators by keeping its members and the public informed about national issues and trends in science education. Members of NSTA include science teachers, science supervisors, administrators, scientists, business and industry representatives, and others involved in science education. The association produces many publications including books, five journals, a newspaper, and a magazine for children called *Dragonfly.* The association conducts national and regional conventions. Also, the association is involved in cooperative working relationships with numerous educational organizations, government agencies, and private industries on a variety of projects (NSTA, 1997).

SOCIETY OF MANUFACTURING ENGINEERS (SME)

Founded in 1932, the Society of Manufacturing Engineers (http://sme.org) is an international professional society dedicated to serving its members and the manufacturing community through the advancement of professionalism, knowledge, and learning. SME offers its members many resources they need to compete in a rapidly changing manufacturing environment. The association provides its members with trade publications, quarterly technical publications and technical reports to help keep them current on manufacturing related applications, processes, technology developments, methods, and regulatory issues. SME offers eleven in-depth association subgroups on specific technologies (e.g., Computer and Automated Systems Association of CASA/SME to meet the needs of members with similar interests. In addition, SME offers its members an opportunity to become professionally certified as a Certified Manufacturing Technologist (CmfgT), Certified Manufacturing Engineer (CmfgE), or Certified Enterprise Integrator (CEI) (SME, 1997).

OTHER PROFESSIONAL GROWTH OPPORTUNITIES

Professionals are individuals who continue to better themselves. They strive to stay current and informed in their chosen field. Professionals who choose to further their education can open "new doors" in their careers. New positions (e.g., at a college or university) or changes in assignments are available to those who choose to complete either a master's or doctoral degree. To help those wanting to further their education, many colleges/universities offer graduate assistantships or fellowships that help to defer the cost of obtaining an advanced degree.

There are many growth opportunities available to technology education professionals. State and college/university-sponsored workshops offer individuals an opportunity to learn about new technologies or curriculum projects influencing the field. For those with specific technology education related interests, there are possibilities of internships or summer jobs. For example, if you teach in the area of communication technology, you may take a summer job or internship in an industry related to communication (e.g., TV or Radio Station). Also, acting as a consultant within your field offers excellent growth opportunities. As a consult, you are considered an "expert" in a chosen area or on a selected topic. Being an expert forces you to stay current—you must be aware of all developments, issues, and trends that are impacting your chosen area of consulting.

As a professional, you must continually obtain and read a variety of publications. Reading association-sponsored publications as well as other publications (e.g., newspapers, national news magazines and trade magazines) helps you to grow professionally. Reading helps keep you current on national and international affairs as well as important issues and trends in your field.

Another growth possibility for the technology education professional is to become involved in student-sponsored associations or clubs. Serving as a education club advisor at either the collegiate or K-12 level can be a rewarding experience. Clubs and student organizations can provide students with opportunities to learn more about technology, and how an organization functions. In his summary on why technology teachers and students should participate in student organizations, Litowitz (1995) lists the following benefits, “1. the development of leadership abilities, 2. professionalism, 3. competitiveness, 4. program recruitment, 5. curricular innovation, and 6. personal satisfaction” (p. 27).

Many schools today have their own technology education clubs which may also be affiliated with a national association. The Technology Student Association (TSA) is the only student organization devoted exclusively to the needs of technology education students who are enrolled in, or have completed technology education courses. Its mission is to prepare them for the challenges of a dynamic world by promoting technological literacy, leadership, and problem solving, resulting in personal growth and opportunity (TSA, 1997).

Professionals in technology education must continually look for other organizations or corporations that offer growth possibilities through their sponsored activities or services. For example, FIRST which stands “For Inspiration and Recognition of Science and Technology” sponsors annual robot competitions for high school students. FIRST is a nonprofit organization whose mission is to generate an interest in science and engineering among today’s youth (FIRST, 1997). The National Aeronautics and Space Administration (NASA) is another excellent example of an organization for those in technology education. Available on-line, it offers a wealth of information on aeronautics and space related topics (NASA, 1997). An example of a corporation that is concerned with technology education is the Learning Institute for Technology Education (LITE). LITE is nonprofit Michigan corporation that serves as a center of resources for Technology Education. It publishes related technology education information and offers in-service workshops for teachers (LITE, 1997).

Grant writing also provides professionals in technology education with growth opportunities. For example, grants can provide individuals with new materials and equipment to upgrade their programs. They can fund special interest projects or provide the individual with money to develop a new curriculum, or attend in-services and conferences. Many states, foundations, as well as national organizations and associations offer grant opportunities. Professionals in the field of technology education must continually seek out possible funding sources and put forth the effort to write a proposal. As Reeve and Ballard (1993) noted, “proposal writing is not difficult, and once learned it can become a very enjoyable task” (p. 31).

Further growth opportunities are available to those who become members of professional fraternities associated with education or technology education. For example, Phi Delta Kappa (PDK) is an international professional fraternity for those involved in education. Its purpose is to promote quality education, with particular emphasis on publicly supported education, as essential to the development and maintenance of a democratic way of life. It provides it members with many professional growth opportunities and timely publications (PDK, 1997).

The premiere fraternity for those professionals associated with technology and technology education is Epsilon Pi Tau (EPT). It is an international honorary fraternity founded in 1929 at The Ohio State University by William E. Warner. Its purposes today are to promote the values and contributions of professionals in technology. EPT provides a medium for the professional development and recognition of individual members for leadership and achievement. Membership into the fraternity is achieved by invitation to those who exhibit outstanding leadership accomplishments, leadership potential, or academic accomplishments. Fraternity publications include, *The Journal of Technology Studies,* a refereed journal, a periodic newsletter, and monographs (EPT, 1997).

SUMMARY

There are a variety of professional associations, organizations, and other growth opportunities for those professionals in the field of technology education. The chapter began by describing the roles of associations and organizations in relation to personal professional development. Next, the importance of joining and encouraging others to join a professional association or organization was examined. Professional associations and organizations in technology education were then reviewed, including an in-depth review of the ITEA. A brief review of state and local associations and organizations was then presented. Other professional associations and organizations available to technology education professionals were then reviewed. Finally, the chapter concluded by reviewing other growth opportunities for those in the field of technology education.

REFERENCES

AVA—Technology Education Division, TED. (1997, August). [On-line]. Available: http://www.missouri.edu/~pavtwww/ted/ted.html

American Association for the Advancement of Science, AAAS. (1997, August). [On-line]. Available: http://www.aaas.org/AAASTXT.htm

American Society of Engineering Education, ASEE. (1997, August). [On-line]. Available: http://www.asee.org.

American Vocational Association, AVA. (1997, August). [On-line]. Available: http://www.avaonline.org

Association for Educational Communications and Technology, AECT. (1997, August). [On-line]. Available: http://aect.org

Association of Curriculum and Development, ASCD. (1997, August). [On-line]. Available: http://www.ascd.org

Barlow, M. L. (1967). History of Industrial Education in the United States. Peoria, IL: Charles A. Bennett.

Council on Technology Teacher Education, CTTE. (1997, August). [On-line]. Available: http://www.odu.edu/~deal/ctte/ctte.html

Epsilon Pi Tau (EPT). (1997, August). [On-line]. Available: http://www.bgsu.edu/colleges/technology/ept/index.html

Evans, R.N. (1988). The history of NAITTE. National Association of Industrial and Technical Teacher Educators.

For Inspiration and Recognition of Science and Technology, FIRST. (September, 1997). [On-line]. Available: http://www.usfirst.org

Graphic Arts Technical Foundation, (GATF). [On-line]. Available: http://gatf.org

Hanson, R H. (1983). Gaining and maintaining professionalism. In R. E. Wenig & J.I. Matthews (Eds.), *The dynamics of creative leadership for industrial arts education.* (pp. 194-217). 32nd Yearbook of the American Council on Industrial Arts Teacher Education. Bloomington, IL: McKnight.

International Technology Education Association, ITEA. (1997, August). [On-line]. Available: http://www.iteawww.org

International Technology Education Association, ITEA. (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: Author.

International Technology Education Association, ITEA. (no date). *Membership in the International Technology Education Association.* [Brochure]. Reston, VA: Author.

Lauda, D. P. (1995). Professional councils and associations. In G. E. Martin (Ed.), *Foundations of technology education.* (pp. 567-594). 44th Yearbook of the Council on Technology Teacher Education. New York, NY: Glencoe/ McGraw-Hill.

Let George Do It. (1942). *The Industrial Arts Teacher,* 1(1), 2

Learning Institute for Technology Education, LITE. (September, 1997). [On-line]. Available:
http://www.remc8.k12.mi.us/teched/index.html

Litowitz, L. S. (1995). Technology student organizations. *The Technology Teacher,* 55(1), 24- 28.

Missouri Industrial Technology Education Association (MITEA). (1997, August). [On-line]. Available:
http://www. Farmington.k12.mo.us/mitea/mitea.htm

National Aeronautics and Space Administration, NASA. (September, 1997). [On-line]. Available: http://nasa.gov

National Association of Industrial and Technical Teacher Educators, NAITTE. (1997, August). [On-line]. Available:
http://www.orst.edu/DEPT/NAITTE

National Association of Industrial Technology, NAIT. (1997, August). [On-line]. Available: http://nait.org

National Science Teachers Association, NSTA. (1997, August). [On-line]. Available: http://www.nsta.org

Phi Delta Kappa, (PDK). (1997, August). [On-line]. Available http://www.pdkintl.org

Reeve, E. M. & Ballard, D.V. (1993). A faculty guide to writing grant proposals. *Community College Journal,* 63(4), 28-31.

Reeve, E. M. (1990). Update: Councils and associations affiliated with technology education/industrial arts. *The Technology Teacher,* 29(5), 25-28.

Society of Manufacturing Engineers, (SME). [On-line]. Available: http://sme.org

Starkweather, K. N. (1995). The International Technology Association. In G. E. Martin (Ed.), *Foundations of Technology Education.* (pp. 543-566). 44th Yearbook of the Council on Technology Teacher Education. New York, NY: Glencoe/McGraw-Hill.

Technology Student Association, TSA. (1997, August). [On-line]. Available: http://www.tmn.Organizations/Ir/tsawww/tsa.html[On-line]. Available: http://nait.org

National Science Teachers Association, NSTA. (1997, August). [On-line]. Available: http://www.nsta.org

Phi Delta Kappa, (PDK). (1997, August). [On-line]. Available http://www.pdkintl.org

Reeve, E. M. & Ballard, D.V. (1993). A faculty guide to writing grant proposals. Community College Journal, 63(4), 28-31.

Reeve, E. M. (1990). Update: Councils and associations affiliated with technology education/industrial arts. The Technology Teacher, 29(5), 25-28.

Society of Manufacturing Engineers, (SME). [On-line]. Available: http://sme.org

Starkweather, K. N. (1995). The International Technology Association. In G. E. Martin (Ed.), *Foundations of Technology Education.* (pp. 543-566). 44th Yearbook of the Council on Technology Teacher Education. New York, NY: Glencoe/McGraw-Hill.

Technology Student Association, TSA. (1997, August). [On-line]. Available: http://www.tmn.Organizations/Ir/tsawww/tsa.html

Teachers for Tomorrow

Chapter 16

William D. Greer
Fort Worth ISD
Fort Worth, Texas
49th CTTE Yearbook, 2000

A student enters the classroom, sits down at a computer, puts on Sega Virtual Reality glasses and a Mattel PowerGlove, grasps a Gravis joystick, and begins to explore the inner workings of a computer or begins to fly around the solar system. Truth, science fiction, or just a humorous perspective on the future? Can this possibly be happening in technology education today? If your answer is yes, are we preparing our teachers to function in this type of program?

During the 20th century, our society moved from the agriculture age to the industrial age; from a goods producing society to an information based society; and now we are a service and knowledge based global society. We know that the societal base will change twice during a student's K-12 education. How can our educational system even address the exponential growth in technology? What should be the specific role of technology education in the process?

We live in a data driven society and some of the data indicate that 50% to 60% of the students entering the labor market in the year 2000 will be employed in jobs that did not even exist when they began school (Witter, 1998). These same students will make major career changes (not jobs) five to seven times during their working adult life. Data also indicates that 5% of the jobs in the year 2000 will require less than a high school diploma, 20% will necessitate a baccalaureate or advanced degree, and 75% will require technical training or an associates degree. Data identifies real problems but now more than ever, we need real solutions. What will be expected of our teachers for tomorrow?

I will address the problems from three perspectives—the classroom setting, instruction, and pedagogy. The development and production of the personal computer are having a dramatic impact on the classroom setting. It is common today to find computers on the desks of most teachers, and computers are readily available to students. The rise in popularity of modular based technology education laboratories has fueled the need for personal computers in our programs. Currently, some of these laboratories are networked and some stand alone, but few are connected to systems outside the classroom.

I predict that technology education classrooms in the 21st century will look substantially different from those of today. They will resemble a research facility with a transparent window to the world. If we expect students to compete successfully in a global society, they must have rapid access to the knowledge base of that society. The stand-alone classroom will become as obsolete as the stand-alone computer. Students and parents will expect the educational community to provide equipment that can easily access local and area wide networks as well as the World Wide Web.

Savage (1998) identified some core technologies that will be shaping the classroom in the 21st century: *(a)* optical data storage devices including advanced compact disk, bar code readers and 3-D holographic crystals; *(b)* advanced computers such as electronic notepads, multimedia computers, telecomputers, parallel processing computers and multisensory robotics; and *(c)* distributed computing incorporating electronic data interchange and desktop videoconferencing. In addition to the core technologies, Savage (1998) identified other technological advances that will have a significant impact: *(a)* fiber optics for telecommunication systems, distributed computing systems, endoscopic technology and virtual retinal displays; *(b)* advanced satellites with low earth orbiting and direct broadcast satellites; *(c)* high-tech ceramics for abrasives, heat shields, ball bearings, engine components and artificial bone implants; and *(d)* fiber-reinforced composites. In order to function in this type of environment, technology education teachers must address the what and how of teaching. For example, the physical change of the classroom and its equipment will foster a significant change in instruction.

Students in the 21st century will be better prepared technologically than students in past centuries. Kindergarten and first grade students will already be using computers to complete elementary level technology activities including research, desktop publishing, simulation, and animation. At various levels of proficiency, students will have been exposed to or possess an in-depth knowledge of computers, telecommunications, desktop publishing, animation, and many other applications of technology well before they begin secondary education. The curriculum will need to be continually updated in recognition of the advanced knowledge and skill students will bring to the classroom.

Today, the World Wide Web is an essential element in obtaining and transmitting knowledge. This resource will become even more invaluable in the future to students and teachers. The exponential growth of technology will mandate that teachers use the knowledge and resources of business and industry, fellow teachers, and the world community in order to enhance their programs. Students will complete assignments in conjunction with students from other cities, states, and countries.

Technology education teachers will need to be self-motivated, flexible, and enjoy working with a diverse group of students. They must also be problem solvers, critical thinkers, and technologically literate. Teachers in the early part of the 21st century must bring to the classroom well developed skills in dispute resolution, motivation, and conflict management in order to cope with the special needs of diverse populations.

Individuals from varied backgrounds or from under-represented gender and ethnic groups will be highly recruited to become teachers. As the demographics of the nation shift, it will be imperative that the brightest of these individuals be encouraged to enter the teaching profession, particularly technology education.

In the 3rd millennium, teachers will be called upon to teach more than just content—they will facilitate the total teaching and learning process. While the move from teacher to facilitator is not a big step, sometimes it can be a difficult one. The facilitator must be able to cope with a variety of learning activities taking place concurrently. Technology education teachers will be expected to integrate learning activities that provide students opportunities to use knowledge learned and skills developed in other classes such as mathematics, science, and language arts. In a large part, these activities will be based in a true problem solving setting. Maintaining a student-centered environment in an experience-based instructional program that includes input from many sources will be a fundamental requirement of the facilitator. The facilitator will have a strong working knowledge of a variety of assessment methods including portfolios, project development, tests and measurement, and documentation procedures. An understanding of the cognitive, affective, and psychomotor domains and the ability to apply them in a variety of settings will be important.

Additionally, a facilitator must understand multiple intelligences such as verbal, mathematical, body, and spatial (Gardner, 1993).

Teachers must be able to communicate effectively in a variety of medias and contexts in order to transmit relevant information, promote their programs, and become an integral part of the education process. Written and oral communication skills will be important and the ability to incorporate all types of communication using many forms of technology will be essential. Teachers will communicate with other teachers, students, administrators, parents, and the community as part of their daily routine. Where will we find the people that I have just described? Who will train them? These questions pose some of the greatest challenges facing the technology education profession today.

As I view pedagogy for the 21st century, I predict it will be in a constant state of change. Technology will drive the curriculum but curricular decisions will drive the purchase of technology for our programs. Curriculum documents will be in a constant state of flux while reflecting many of the new and innovative programs for students. The emphasis will be on learning outcomes rather than skill specific results.

The Secretary's Commission on Achieving Necessary Skills (SCANS) report (1991) and its supporting documents provide a clear picture on what is expected as we draw closure on the 20th century. Many of the skills identified by SCANS will be required in the 21st century. Specifically, these skills include the Foundation Skills of Basic Skills, Thinking Skills, and Personal Qualities as well as the SCANS Competencies of Resources, Information, Interpersonal, Systems, and Technology.

Curriculum will need to be developed to prepare students for a world in which workers are empowered in decision making processes and who are working in self-directed and self-motivated positions. Students will be required to know a variety of technologies and to use those technologies to complete activities. The concept of life-long learning will be incorporated into the curriculum. The question of whom will set the framework of the curriculum in the future needs to be answered. Will it be national standards, state standards, or even local education agencies? Will standards be voluntary or mandatory? Will there be models for teachers to follow? What will be the role of universities, businesses, industries, technical schools, and state agencies in developing research and curriculum documents?

The classroom instructional program will no longer be the domain of just the technology education teacher. It will be the result of a consensus building process involving teachers, parents, students, and the community. The program will be driven by an ever-changing technology. The future is exciting and challenging for tomorrow's teachers. It might be stated that the word tomorrow will be the byword of our teachers, for as tomorrow changes, so will all of their future tomorrow's. The one constant in their professional and personal lives will be change, and this will be even truer for the future of the students with whom they have been charged.

P.S. If you want to see the classroom described in my opening paragraph, visit Kelly Walsh High School in Casper, Wyoming. They have had the program since 1993.

REFERENCES

Booth, S. A., Ronge, L. J., & Vizard, F. (1996, September). VR in the Classroom, *Popular Science,* 249(3), 62.

Gardner H. (1993). *Multiple intelligences: The theory in practice.* New York: Basic Books.

Savage, E. (1998). *Some thoughts on technology education year 2000 and beyond.* Paper presented at the Technology Education Professional Improvement Conference, Corpus Christi, TX.

The Secretary's Commission on Achieving Necessary Skills (1991, June). *What work requires of schools.* Washington, DC: United States Department of Labor.

Witter, B. (1998, July). *The truth about career decision making.* Paper presented at the Technology Education Professional Improvement Conference, Corpus Christi, TX.

INDEX

C

D

Q

R

S

U

V

W