INSTRUCTIONAL STRATEGIES FOR TECHNOLOGY EDUCATION

1988

Council on Technology Education

37th Yearbook

INSTRUCTIONAL STRATEGIES
FOR
TECHNOLOGY EDUCATION

INSTRUCTIONAL STRATEGIES FOR TECHNOLOGY EDUCATION

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37th Yearbook, 1988

Council on Technology
Teacher Education

Glencoe Publishing Company
15319 Chatsworth Street
Mission Hills, CA 91345

Printed in the United States of America

Orders and requests for information about cost and availability of yearbooks should be addressed to the company.

Requests to quote portions of yearbooks should be addressed to the Secretary, Council on Technology Education, in care of the publisher, for forwarding to the current Secretary.

**This publication
is available in microform.**

University Microfilms International

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

ISBN 0-02-677114-4

Foreword

The success and growth of the Council on Industrial Arts Teacher Education, and now the Council on Technology Teacher Education, has been and continues to be dependent on the involvement of the membership. The Yearbook series is an integral part of this success thanks to the involvement of the editors and authors since the first Yearbook in 1952. The Yearbook you have in your hands is number 37 of that series.

It is one thing to have a philosophy from which to work, but it is another to have well designed strategies ready to implement one's ideas. It is no wonder that faculty members clamor for new approaches that they can use in the classroom. The editors designed a yearbook to provide information on teaching concepts, interdisciplinary approaches, means to include the social/cultural impacts of technology, problem solving, and understanding of systems and ideas for the study of industry. The authors accepted the challenge and have provided information that can be used immediately and that is based on a good deal of commonsense.

Yearbook 37, Instructional Strategies for Technology Education, comes at a unique period in the transition from Industrial Arts Education to Technology Education. The editors, Drs. William H. Kemp and Anthony E. Schwaller, are to be complimented for their foresight in developing this important yearbook. The authors of the thirteen chapters are to be commended for providing unique insights into the delivery of Technology Education.

The Council also recognizes the support from Glencoe Publishing Company. Their commitment to success in technology teacher education continues to make a significant impact on our discipline. To the leadership of Glencoe Publishing we extend our genuine appreciation.

I feel honored to have served as your President from 1984-88 and to have witnessed the phenomenal contribution provided by our Yearbook editors and authors. Your efforts are a real tribute to the beneficiaries of your work—the students which we all serve. Thank you for allowing me to be a part of this effort.

March 1988

Donald P. Lauda
President, CTTE

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Yearbook Proposals

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

CTTE Yearbook Committee

CTTE Yearbook Guidelines

A. Purpose:

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

B. Yearbook topic selection criteria:

An appropriate Yearbook topic should:

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

Proper yearbook themes *may* also be structured to:

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

C. The yearbook proposal:

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

Previously Published Yearbooks

*1. *Inventory Analysis of Industrial Arts Teacher Education Facilities, Personnel and Programs,* 1952.
*2. *Who's Who in Industrial Arts Teacher Education,* 1953.
*3. *Some Components of Current Leadership: Techniques of Selection and Guidance of Graduate Students; An Analysis of Textbook Emphases;* 1954, three studies.
*4. *Superior Practices in Industrial Arts Teacher Education,* 1955.
*5. *Problems and Issues in Industrial Arts Teacher Education,* 1956.
*6. *A Sourcebook of Reading in Education for Use in Industrial Arts and Industrial Arts Teacher Education,* 1957.
*7. *The Accreditation of Industrial Arts Teacher Education,* 1958.
*8. *Planning Industrial Arts Facilities,* 1959, Ralph K. Nair, ed.
*9. *Research in Industrial Arts Education,* 1960. Raymond Van Tassel, ed.
*10. *Graduate Study in Industrial Arts,* 1961. R. P. Norman and R. C. Bohn, eds.
*11. *Essentials of Preservice Preparation,* 1962. Donald G. Lux, ed.
*12. *Action and Thought in Industrial Arts Education,* 1963. E. A. T. Svendsen, ed.
*13. *Classroom Research in Industrial Arts,* 1964. Charles B. Porter, ed.
14. *Approaches and Procedures in Industrial Arts,* 1965. G. S. Wall, ed.
15. *Status of Research in Industrial Arts,* 1966. John D. Rowlett, ed.
16. *Evaluation Guidelines for Contemporary Industrial Arts Programs,* 1967. Lloyd P. Nelson and William T. Sargent, eds.
17. *A Historical Perspective of Industry,* 1968. Joseph F. Luetkemeyer, Jr., ed.
18. *Industrial Technology Education,* 1969. C. Thomas Dean and N.A. Hauer, eds. *Who's Who in Industrial Arts Teacher Education,* 1969. John M. Pollock and Charles A. Bunten, eds.
19. *Industrial Arts for Disadvantaged Youth,* 1970. Ralph O. Gallington, ed.
20. Components of Teacher Education, 1971. W. E. Ray and J. Streichler, eds.
21. *Industrial Arts for the Early Adolescent,* 1972. Daniel L. 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 R. Thomas Wright, eds.

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

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Preface

In order for any discipline to accomplish its goals, the content as well as the instructional strategies must be continuously researched and updated. If technology education is to succeed in the future, new instructional strategies must be incorporated into both secondary and post secondary classrooms and laboratories. This yearbook provides the teacher with new and improved instructional strategies for technology education.

The yearbook is divided into four sections. The first section has been written to emphasize the need for technology education. It contains a description of the structure of the yearbook, a review of several learning theories and a model of student needs. Information about learning theory and student needs is critical when selecting and implementing innovative instructional strategies.

The second section addresses several approaches that are recommended as instructional strategies for technology education. Approaches to teaching technology education are closely aligned with the goals of technology education. They include the teaching of concepts, using an interdisciplinary approach, emphasizing social/cultural impacts of technology, developing problem solving skills, being able to integrate the systems of technology, and interpreting industry. It is suggested that the technology teacher incorporate as many of these approaches as possible into the classroom and/or laboratory.

The final chapters of this yearbook analyze several delivery systems that are recommended for technology education. Delivery systems are the actual way or method that the teacher presents the content. Lectures and demonstrations; group interaction; discovery, inquiry and experimentation; and games/simulation are all viable delivery systems for teaching technology content. Depending upon the exact content, one or more of these delivery systems should be incorporated with one or more of the approaches presented in Section Two.

The final section suggests several ideas and concepts about instructional strategies that still need more research. In order to keep technology education growing, more research and development concerning in-service models are needed. Both secondary and post secondary technology education faculty need continous training in new and innovative instructional strategies.

The future of our field lies in understanding contemporary instructional strategies as well as the content for technology education. Neither one is more important than the other. However, both link closely together to make technology education successful. We sincerely hope the information presented in this yearbook gives teachers ideas and motivation to try new and innovative instructional strategies. Without this effort, the success of technology education may be minimized.

William H. Kemp
Anthony E. Schwaller

Acknowledgments

The editors wish to express thanks and sincere appreciation to everyone who helped make this project possible. A publication such as this requires a great deal of effort on the part of many individuals. It has been a pleasure working with these professionals.

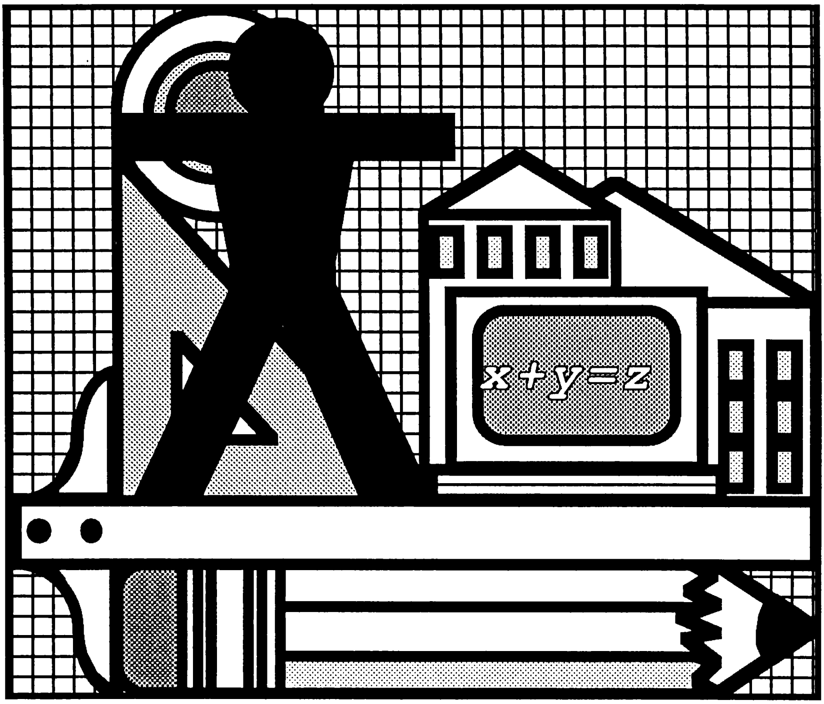
A special thanks is extended to the authors who wrote each of the chapters. All of the authors worked diligently to meet our expectations and deadlines. Without their dedicated effort and professionalism this yearbook would not have been possible.

In addition, several other people deserve thanks for their roles. Our wives, Marlene and Renee, deserve credit for their continued support and encouragement during the two-and-one-half years it took to complete this project. We are also grateful to Dr. Louise Johnson, Dean of the College of Science and Technology, for her continued support. Special thanks should also go to Mary Fugleberg for typing the manuscript, and Wes Stephens for help in editing the yearbook manuscript. In addition, we are grateful to Mary Shrode and Rich Josephson, Learning Resource Center, St. Cloud State University, for preparing the artwork for this yearbook.

Finally, we express our gratitude to Glencoe Publishing Company for their information and assistance throughout the project.

William H. Kemp
Anthony E. Schwaller

SECTION 1:



INTRODUCTION

SECTION ONE

Introduction

Section 1 is designed to provide an introduction and overview of this yearbook. Chapter One, *Technology Education*, helps the reader understand the broad concepts of technology education. Technology, technology education and technological literacy are defined and a distinction is made between traditional industrial arts and technology education. Chapter Two, *Introduction to Instructional Strategies*, explains the overall format of the yearbook and the terms Approaches and Delivery Systems are defined. Finally, Chapter Two introduces two important concepts, learning theory and student needs. These concepts are presented so the reader is better able to understand the remaining chapters.

CHAPTER ONE

Technology Education

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Unfortunately for students in the 1980's, many in academia have been more concerned about what the future held in store for education than in what education could do for the future. Too many students focused on what Bloom (1980) called unalterable variables. All disciplines must regularly address change and make rational adjustments, not only in their choice of content, but also in their instructional strategies. This requires conscious attention to the realities of our culture today and as they unfold tomorrow.

Like the 1986 Yearbook, the 1988 Yearbook was designed to help the reader understand and implement technology education. This yearbook is especially geared to help the practitioner develop and use appropriate instructional strategies. One may ask if technology education mandates different instructional strategies than those used in traditional industrial arts. If the answer were negative, this Yearbook would not be needed. There is a distinct difference between industrial arts and technology education. As a result, content and instructional strategies are indeed different. This introductory chapter was written to define technology education while showing its direct contribution to the development of students in a technological society. It demonstrates a need for a new way of approaching the teaching of technology in our schools.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Define the following terms:
   Technology.
   Technology education.
   Technological literacy.

2. Articulate the difference between industrial arts and technology education.
3. Articulate the need for instructional strategies in technology education which differ from traditional industrial arts.

TECHNOLOGY EDUCATION DEFINED

Defining the term technology may seem unnecessary since we all use it every day and we teach about it. Yet the term remains elusive and misconceptions result. Sahal and Nelson (1981) stated:

> The term technology is often envisaged in terms of universals. It has numerous connotations, ranging from an object of material culture to the pool of applied scientific knowledge. The difficulty with some of these popular notions of technology is that they are so broad as to defy any useful operationalization of the concept. Indeed, they are no more informative than is the truism that all uncles are males (p.15).

To understand the concept of technology education one must investigate the progression of human development. This is essential since the means humans have used for adapting to their environment is the very basis for choosing content in the discipline. To dismiss this leads to confusion and misconceptions about the transition from industrial arts to technology education.

The progression of humankind cannot be explained, or even studied, solely from a biological perspective. Unlike other forms of life, the human had the capacity to *adapt* to environmental conditions. Lauda and McCrory (Jones and Wright, 1986) stated that "culture is the human's unique way of adapting to the natural environment" (p. 16). The symbolic nature of culture allows humans to transmit it from generation to generation. At the same time it is accumulative as humans gain new knowledge and new ways of doing things. It is the means through which we have adjusted and will continue to adjust in the future. It is imperative, therefore, that the educational system take into account the realities of our culture.

Adaptive Systems

Each of these two words, *adaptive* and *systems*, has specific meaning for technology education. Again, it must be emphasized that comprehension of these is essential to comprehend the intent and potential of technology education. Much of the debate over the merits of technology education can be contributed to lack of such understanding.

The term *adaptive* refers to the ability to adjust to new or changed circumstances. The human has spent great amounts of energy adjusting to both natural and human-made environments. As our technology continues to expand, additional adjustments will be necessary. Humans are constantly adjusting to the consequences of their creations. For example, we are still trying to adjust to the merits, as well as to the negative consequences, of nuclear power.

Systems are a set of objects or constructs which are interconnected in a dynamic relationship. This interdependent nature of all variables gives structure and cohesion to the system. Thus, to study one part out of context of the whole leads to misinterpretation. The alteration of one element of a system leads to change in the system as a whole.

Many scholars, such as Fletcher (1981), Bierstedt (1974), Lenski (1970) and White (1959) agree that the basic human adaptive systems used over time are: (1) ideological, (2) sociological and (3) technological. The reader is encouraged to read Chapter One of the 1986 ACIATE Yearbook, *Implementing Technology Education*, for a description of these systems. It is the technological system to which we will turn our attention.

The word *technology* must be divided into two parts in order to understand its complexity. These are *techno* (technical means) and *logy* (study of). In other words, the term refers to the *study of our technical means*. The term *technology* is used in everyday language to refer to the contrivances we use for everyday living for survival. These did not appear without human action. Early humans elicited from naturally occurring material new forms of potential. They moved from trial and error to the use of knowledge which allowed for greater precision, complexity and potential.

It is from such thinking that technology education advocates draw their philosophical base. It was such thinking that provided the base for the Jackson's Mill document in 1981 (Snyder and Hales). With the literal survival of the human race contingent upon adaptive systems, it is logical to seek content and instructional strategies that help students comprehend those systems. In the case of technology education, the primary focus is on the technical means but does not disregard ideological and sociological. It is essential that the total system be analyzed so the student understands how technical means work as well as how they impact our lives. Thus, it is imperative that the ideological and sociological conditions that surround invention and innovation be explored simultaneously with the technological systems. Any discussion of a technical means involves the emergence of other content and instructional strategy potential.

Technology Defined

The study of the technical means used for survival. Such study includes the origin, nature of, structure and use of human contrivances in a societal context.

Technology Education Defined

A comprehensive, action-based educational program concerned with technical means, their evolution, utilization, and significance; with industry, its organization, personnel systems, techniques, resources and products; and their sociocultural impact (AIAA, p. 25).

Technological Literacy Defined

A new way of thinking which creates a whole new "world view"— that is, understanding that modern technology is itself a new organization of meanings, and assumptions about the world and human life. It involves technical skills as well as knowledge of socio-technical systems—the sort of thinking that alters culture, forces a new way of life, a new morality and a new purpose for human beings (Lauda, 1978).

NEEDS OF SOCIETY IN THE FUTURE

Most writers would agree that it was following World War II that our civilization witnessed the development of landmark technical developments which impact us even today. Ramo (1983, p. 3) stated:

> Our century might also be labeled the "century of technology," although obviously the twentieth will not stand out as the only century affected by technological advance. Technology has been with us since before the invention of the wheel, and the future society certainly will find itself under the spell of more scientific discovery and technological development that we have so far known. But ours may go down as the century of technology because it will be seen that in the 1900's society did more that incorporate its share of technological advances - it became a *technological civilization.*

Ramo (p. 4) also reminded us that this was the first century in which we began to understand that technological advance provides not only benefits but also disbenefits. Once we learned that we could convert mass to energy, society was bound to undergo radical change. Society never adjusted completely so unfinished business remains and is compounded daily by new dislocations caused by rapid change. Even if we were to use our technology solely for peaceful purposes, would we be immune from the misuse of our technical means?

In spite of all of our progress we are still unable to produce a job for everybody. We learned in the 1950's that most of the growth in output in the United States could not be accounted for by measuring capital and labor inputs. It was some form of technical progress that accounted for the rapid change. Solow (1957) in his classical work attributed only 12.5% of the growth of output per man-hour to increased use of capital and the remaining 87.5% to technical change. Technical progress leads to the development of a system which opens opportunities for further development. Sahal (1978) regarded the interaction of technical change and system formation as the most essential key to understanding all processes of long-term change. The history of our technological development is based on a process of learning by experience. Thus, it is important to consider the history of our technical means in our discipline if we want to comprehend how societal change occurs as a result of rapid change.

THE INFORMATION SOCIETY

In the 1960's we referred to the *post-industrial society*. Today we refer to the *information society*. Toffler (1980) and other futurists agree that the current generation lives at the confluence of this transition. Toffler referred to knowledge, as well as the people who generate and use it, as the capital asset of the latest transition; or as he called it, The Third Wave. Cross (1985) supported this when she stated:

> Ironically, the age of technology is necessarily the age of development of human resources. Unlike the fossil fuels that provided energy for the industrial revolution, the technological revolution is fueled by information that is a nondepletable, expandable resource. Moreover, it is self-generating, the more people use it, the more it expands (p. 10).

Masuda (1981) felt that the information society would be different than the industrial society because the production of information values and not material values would be the driving force behind the formation and development of society. Past systems of innovation technology he said, have always been concerned with material productive power, but the future information society must be built within a completely new framework, with a thorough analysis of the system of computer-communications technology that determines the fundamental nature of the information society.

The growth of information is evident in all segments of society. The American Association of Publishers reported in 1985 (Simora, 1986) that total receipts by book publishers came to more than $9.121 billion in 1984. This represents the sale of 2.168 billion books. Hall and Brown (Thompson, 1982, p. 35) estimated that the total on-line bibliographic databases contained over 70 million references in 1981, with about 10 million references added annually. Allowing for duplication between databases, they estimated that there were some 40 million unique references searchable on-line with a further 6 million added annually. It is interesting to note that 34 million references were available in the applied sciences, while the pure sciences contained 22 million.

It will be the information industries (Cordell, 1985) that will contribute the major part of the future GNP. Goods will be sold as part of a total information package. Information is the raw material of the new economy and is central to all productive enterprises. Cordell stated that the corporation is slowly evolving into a kind of information system that transforms data from various sources into the capital knowledge base on which the corporation ultimately rests.

High Technology

The information society is dependent on the development of high technology. It is also safe to state that the reverse is also true. Many misconceptions exist about the concept of high technology, the most important of which is that most workers will be employed in high technology jobs. Current research reveals that workers will work in high technology industries, but few will hold high technology jobs. Rumburger and Levin (1985) reported that:

> Regardless of the definition, high technology industries currently employ only a small fraction of the total work force, and they will continue to employ a small fraction in the future. Even the largest grouping of high-tech industries employed only 13 percent of the work force in 1982 and will provide only 17 percent of the new jobs in the period between 1982 and 1995. More restrictive definitions indicate that high-technology industries will provide only three to eight percent of the new jobs in the future economy (pp. 410-411).

Riche, et al. (1983) writing in *Monthly Labor Review* stated that although high technology jobs will increase in numbers, the contribution of high-tech industries to total job growth will be relatively small. Rumburger and Levin (1985, p. 412) reported that of the ten occupations with the fastest absolute growth, none is related to high technology. Of the forty job categories expected to account for half of all new jobs, only about five percent of the occupations require a college degree. This supports the Bureau of Labor Statistics which reported that only three percent of all employment in 1982 was in high-tech occupations. Employment in high-tech jobs was expected to increase by forty-six percent between 1982 and 1985, but account for only six percent of the new jobs in the economy. The Bureau of Labor Statistics (National Advisory Council on Continuing Education, 1984) placed the percent of new jobs in high-tech at seven percent.

Although the contribution of high technology to the work force will remain low, technological change will have a dramatic impact on millions of jobs. At least fifty-five percent of all workers in the immediate future will require a competent grasp of information technologies. In spite of the fact the United States has the most highly educated workforce in its history, with the average worker having 12.7 years of education, the educational system must change to accommodate the information society.

Business/Industry Response

Many corporations chastise the educational system for failing to provide appropriate education for today's workforce. Some chastise the three million public high school students taking vocational education courses that offer specific training. They say it is too narrow, too specialized, therefore leaving the graduate inflexible in a changing workplace. Perelman (1986) stated that the nation that is first to adopt a high-technology, consumer-based learning system will enjoy a permanent competitive advantage in the global economy of the information age.

In spite of the fact that per-pupil spending on public elementary and secondary schools grew by 22.5% in the past decade, business and industry feel they must respond with their own education and training systems. Perelman (1986) estimated that employers invest in training and education some $80 billion a year. This is expected to grow twenty to thirty percent by 1990. Some experts, he said, feel that a fifth of these expenditures are required simply to compensate for the failure of the public schools (p. 14). The ASTD (American Society of Training and Development) placed the contribution of business and industry to training even higher (U.S. News & World Report, 1985, p. 44). Their estimate was that companies spend $210 billion a year training employees either in formal sessions or on the job. About two-thirds of the training comes from employers and the other third from outside sources. They estimated that 300,000 full-time and part-time instructors, consultants and authors are involved. ASTD estimated that within a decade spending on training could reach $600 billion a year and the number of outside trainers could total one-half million.

Cross (1985, p. 9) reported that industrial and governmental agencies offer more than 2,000 courses that are endorsed by the American Council on Education as worthy of academic credit. In the past decade at least eighteen new corporate colleges have been recognized by appropriate state agencies to offer associate, bachelors and masters degrees. Corporations spend more on the education and training of employees than all 50 states combined spend on public higher education.

It is well known that a well educated workforce more than pays for its higher salaries by adding to the value of the products and services it produces. The problem educators face is creating and sustaining an environment in which large numbers of people become educated and remain well educated. General Motors Corporation has predicted that fifty percent of its workforce in the year 2000 will be categorized as skilled tradespersons (technicians, inspectors, monitors, etc.) compared with sixteen percent in 1980 (Best, 1984, p. 61). While some of these new tasks might not require greater skill, many necessitate an understanding of new and more complex technologies. The implications for education are clear. We need a shift away from our unrelenting emphasis on the acquisition of information to the *utilization* of information.

EDUCATION FOR CHANGE AND THE FUTURE

The Carnegie Forum's Task Force on Teaching as a Profession said our educational system doesn't need repairing, but should be rebuilt in order to prepare our children for living in the 21st century. We are loathe to accept such an indictment, but we must analyze our current system and be willing to acknowledge change. Citizens of the remainder of this century and the 21st century must be equipped with: (1) certain basic skills, (2) a desire for life-long learning and (3) values which enable them to perpetuate the goals of the larger society.

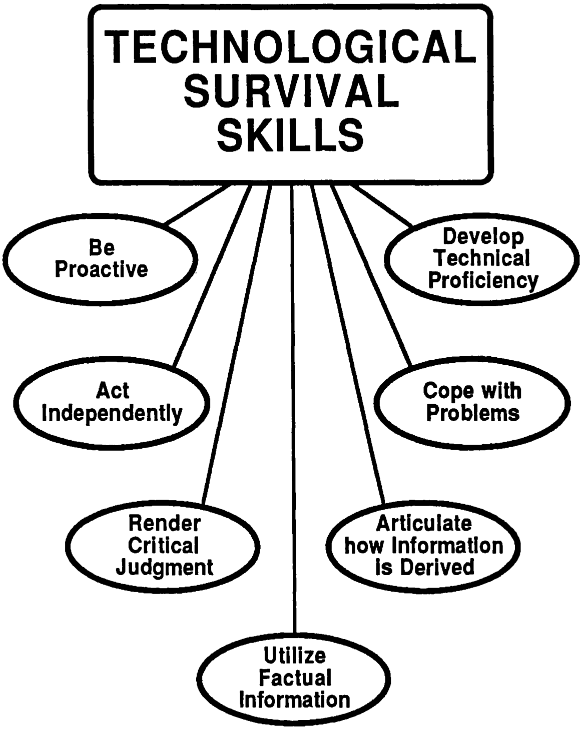

Figure 1-1: These are the technological survival skills needed in a technology curriculum.

Basic Skills

The acquisition of literacy and fundamental computational skills is assumed as a requisite for survival. As shown in **Figure 1-1**, equal attention must be given to the ability to:

1. Be proactive, that is, to detect problems and determine appropriate solutions.
2. Act independently and with others in group problem solving activities.
3. Render critical judgment and offer constructive options.
4. Utilize factual information to carry out basic procedures.
5. Articulate how their factual knowledge is derived and how basic procedures work.
6. Cope with complicated and unfamiliar problems.
7. Achieve proficiency with the technical means.

Achieving proficiency with the technical means was not placed at the bottom of the list because it was to be de-emphasized. Quite the contrary. Survival in a technological world requires proficiency in the use of the technical means. All cultures advance through the use of tools and materials and this requires specific skills. As indicated earlier in this chapter, this is the fundamental basis for technology education.

In an industrial society one could practice a skill without having knowledge of the principles involved. Workers were assigned to routinized tasks which mandated manual dexterity as the primary requisite. To practice a skill in the information society, knowledge is required; therefore, skills—both cognitive and psychomotor—are components of technology. Today's employee is expected to be proactive in detecting problems and determining alternate solutions. Knowledge must precede the acquisition of skills, and the more complex the culture, the more knowledge is needed for production of goods and services. Curriculum developers in technology education must consider the laboratory their primary focus and consciously address the need for skills and the principles behind them. Technology is the basis of the content in technology education and also the means by which it is taught.

The list of survival skills is the basis of technological literacy which must be the ultimate goal of technology education. In summary this list is designed to help individuals entering the workforce to figure out what they need to know, where to get it and how to use it in their productive activity.

Life-Long Learning

Students must leave the public schools with the desire and intent to gain new knowledge and skills the rest of their lives. The current educational system was designed to conclude at the end of twelve years of formal schooling, followed by a precise number of years in college or training schools. The information society will not permit such a luxury. Individuals must continue to learn as the technologies increase in number and complexity. Those who do not internalize this need will certainly become the underemployed, if not the unemployed.

To internalize this need mandates that the K-12 years become a *learning* system rather than a schooling system. Such a mentality places a great responsibility on the curriculum developer. Emphasis must be placed on instructional strategies as well as on content. To some extent the strategies used are far more important than the content itself. For example, the spirit of inquiry (see Chapter Eleven) must be instilled and the potential motivation inherent in working with our technical means will make the job much easier.

Values

Technological growth requires a great deal of responsibility. It mandates that students entertain ideas involving outcomes caused by human decisions. Traditionally, this has been neglected in the discipline of industrial arts. Technology education, on the other hand, is designed to help the student comprehend the consequences (outputs) of technological choices.

In some respects the liberal studies have made greater progress in incorporating a study of the technical means into their curricula than industrial arts educators have done in incorporating sociocultural (see Chapter Five) issues into their curriculum. Courses incorporating technological concepts began to appear in the 1970's in the liberal studies and today such content frequently appears in science education. Stephen White (Kanigel, 1986) wrote:

> To believe, in this era, that a man posesses a liberal education who is ignorant of analytical skills and technological skills is to make a mockery of the central concept of liberal education.

Chen and Novik writing in *Science Education* (1984) stated that the main objectives of scientific and technological literacy are not attained by the majority of the population. In its absence, the citizens of the future will be unable to appreciate the role of their own decisions, as well as those of others, concerning values and actions which shape the environment (p. 424).

Technology education does not have a monopoly on the study of our technological society. However, it does have the responsibility for taking part in it. In essence technological study is needed no matter what a person chooses to do with his or her life. The Stanford Institute for Research on Educational Finance and Governance report, "The Educational Significance of High Technology," stated:

> The general educational requirements for creating good citizens and productive workers are not likely to be altered significantly by high technology. Everyone should have strong analytic, expressive, communicative, and computational skills as well as extensive knowledge of political, economic, social and cultural institutions. These aptitudes and knowledge are required for understanding daily experience and for ensuring access to social opportunities. To the degree that the present schools fall short of providing these results, they should be sought for their own sake rather than because of the claim they are required for a high technology future (NACCE, p. 8).

The discipline of technology education has the distinct advantage of working in laboratories designed to work with the technical means. Such an environment provides the perfect avenue for accomplishing the basic skills listed above. Interdisciplinary efforts (see Chapter Four) merely compound the opportunities open to teachers and students.

TECHNOLOGY EDUCATION - AN ANSWER

Industrial arts education responded to the needs of an industrial society throughout the years. It did this exceptionally well and made significant contributions to the total educational system. Thousands of children have benefited from the programs offered. However, the needs of society change and this calls for reform. Living and working in a technological society calls for extensive reform if the discipline is to maximize its potential. The implementation of technology education represents that response and it too must be in a constant mode of responding to change.

Curricular design in technology education has responded to the realities of our culture, at least in theory. Full application is yet to be realized in most parts of the country. Theoretically, the concept is sound and it is achievable. By design it interprets our technical means, its evolution, utilization and significance. It addresses the primary technical activities of the human (construction, communication, manufacturing, energy/power and transportation). It is designed to help students understand the resources used for technical achievement (input), how it is utilized (process) and the significance (output).

Even the best curriculum design will fail if the instructional strategies are inappropriate or inadequate. This is the key to success and it is the intent of subsequent chapters to help the reader achieve her/his goals as a technology education teacher. Business/industry has specific needs as described in this chapter. Various activities in technical laboratories provide the opportunity for problem solving (see Chapter Six) activities in the technologies. Achieving this objective will meet one of the greatest needs of business/industry today and in the future. The teacher must become a resource to help students become individuals who ultimately *think for a living.* This must be the goal of all disciplines, but through technology education we can help people live in a technological environment as well as function as citizens in an interdependent world.

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CHAPTER TWO

Introduction to Instructional Strategies

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Technology education has been a topic of discussion for a number of years. However, very few articles have been written or research projects completed in the area of "How to Teach Technology Education." This yearbook is intended to fill that void. In this chapter the concepts of instructional strategies are introduced and their relationship to technology education is shown. The overall format of the yearbook is described and critical terms are defined. In addition, the foundations of learning theory and student needs are discussed as an integral part of instructional strategies. A conceptual model is introduced that shows how all chapters are related. This model includes the interrelationships between "Approaches to Teaching Technology Education" and "Delivery Systems for Teaching Technology Education."

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Define the term "instructional strategies" as used in technology education.
2. Explain why the study of instructional strategies is important in preparing to teach technology education.

3. Define the term "approaches" as used in technology education.
4. Define the term "delivery systems" as used in technology education.
5. Describe the relationship between approaches to teaching technology education and delivery systems for teaching technology education.
6. State how the objectives and content of technology education help dictate the instructional strategies used.
7. Explain the importance of understanding student needs when teaching technology education.
8. Explain the importance of applying learning theory to teaching technology education.

NEED FOR NEW INSTRUCTIONAL STRATEGIES

What are Instructional Strategies?

Once a teacher has established the goals for a course and the content has been identified, selected and developed, a plan must be established to transmit the knowledges, skills and attitudes to the students. The total plan may include several facets to ensure that everything interrelates and becomes a reality. This *master plan* for managing and facilitating the learning environment is accomplished by employing instructional strategies. It includes all of the elements necessary in the teaching/learning process. Certainly the way the material is presented, known as the "delivery system," is a very important part of this total plan, but it is not the only part. The total scheme is important and includes curriculum development, laboratory planning, evaluation, etc., in addition to the delivery system to be used in the actual teaching process.

Today's technology education teacher must employ a wide variety of instructional strategies in order to be effective. The teacher's role has changed in the past twenty-five years to that of a manager or facilitator of learning, rather than purely a dispenser of facts and information. For this reason it is mandatory that the contemporary technology education teacher know as much about instructional strategies as possible.

Why are New Instructional Strategies Needed?

The course content for contemporary technology education programs may be accurately identified, selected and developed; however, it will not be effectively transmitted unless the instructor provides the right environment and opportunities for the students to learn the content. Today's content is different from yesterday's content, as indicated in Chapter One. Therefore, different instructional strategies are needed if effective learning is to take place. Teachers simply cannot develop and/or transmit contemporary knowledge, skill and attitudes needed by students in the latter part of the twentieth century and beyond, using outmoded methods of teaching. Instructional strategies must keep pace with and match the technological content that is to be taught to the technology education student.

One of the major concerns is that regardless of the delivery system selected, it must make the student an active participant rather than a passive spectator. Instructional strategies that are action and interaction oriented will bring about improved learning and achievement.

New learning theories are continually emerging to respond to the needs of individuals. Today, in a society bombarded with untold advances in technology, we must call upon the very latest research and knowledge available on how people learn. Therefore, it is absolutely necessary that contemporary instructional strategies incorporate the latest and most appropriate learning theories.

What Determines the Selection of Instructional Strategies?

Many factors play an important role in determining the appropriate instructional strategy to use in a given situation. Perhaps the most important factor is the content to be delivered to the students in the course under consideration. However, content is not the only determinant. Before one can identify, select and develop the precise content for a given course, other items must be considered.

Everyone has a philosophy of life, of education, of technology education, etc. Before analyzing the kind of instructional strategy used, one must first review his/her beliefs about education and the specific curriculum in question. An educational philosophy gives direction to the professional educator for all pedagogical considerations. Basically, it provides the foundation upon which the teacher builds and develops the overall goals of technology education. Philosophy gives direction in formulating measurable objectives, selecting content for specific courses, developing evaluation plans for determining student progress and teacher performance, and planning the physical facility within which the courses will be taught. Philosophy is a very important part—an essential—of the overall scheme.

As stated earlier, content is one of the most important factors in determining the best instructional strategy for a particular situation. The teacher may find that to cover certain content, one strategy is most effective. However, in addressing another type of content, an entirely different strategy or combination of strategies may work better. The point is that no one strategy is appropriate for all situations. There is a wide variety of content included in technology education. This makes it imperative that professional technology education teachers understand all of the contemporary instructional strategies available. The technology education teacher must become proficient in the use of each, but more important, know which instructional strategy is most appropriate for the content that is to be transmitted to the students in a given situation at a specific time.

DEFINITIONS OF RELATED TERMS

In this yearbook two terms are used to describe instructional strategies. These two terms are: (1) Approaches to Teaching Technology Education and (2) Delivery Systems for Teaching Technology Education.

Defining Approaches to Teaching Technology Education

As the technology teacher begins to plan his/her teaching style, certain approaches to teaching begin to emerge. These approaches may be considered pathways to teaching or ways in which content can be looked at or managed. They will help the student accomplish certain goals. In this yearbook "approaches" are defined as broad styles of teaching that relate directly to the goals of technology education. These approaches help to identify a broad plan of action to help accomplish the teaching of technology education.

Defining Delivery Systems for Teaching Technology Education

Delivery systems are defined as the actual methods which the technology education teacher uses to present the content. A delivery system is the method or way in which technology education content is conveyed to the students.

DESCRIPTION OF SPECIFIC APPROACHES AND DELIVERY SYSTEMS

Approaches to Teaching Technology Education

When a teacher has decided to incorporate technology education content in the laboratory or classroom, several approaches to teaching become identifiable. The technology teacher has certain goals which guide him/her in determining how to approach the content of technology education. All of the following approaches should be considered when teaching technology education:

1. Conceptual Learning Approach.
2. Interdisciplinary Approach.
3. Social/Cultural Approach.
4. Problem Solving Approach.
5. Integrating the Systems of Technology Approach.
6. Interpretation of Industry Approach.

Conceptual Learning Approach—An important approach (and thus a goal) to teaching technology education is *conceptual learning*. The concept style of teaching involves identifying common concepts that are an integral part of the content of technology education and then teaching these concepts rather than teaching content only. The technology teacher applies the content to the appropriate concept. If the students have a firm understanding of the concepts of technology education, the teacher will easily be able to add new content as it is developed. If a conceptual base is established in the systems of technology, solutions to complex technical problems (as indicated in Chapter One) can easily be determined.

Interdisciplinary Approach—Interdisciplinary teaching is another approach that should be used by the technology education teacher. Interdisciplinary teaching is the process of relating other disciplines to technology education content. This is done by selecting common topics from other disciplines, and combining them with technology education content to show the interrelationships. Interdisciplinary teaching is important in all technological systems. Other curricular areas that relate to these systems include the sciences, mathematics, arts, environmental studies and mass communications. If one is truly to teach technology education, these areas must be included in the content.

Social/Cultural Approach—One major difference between traditional industrial arts and contemporary technology education is the inclusion of the *social and cultural aspects* of technology. This approach helps the students to understand the relationship between technology and culture. This includes how technology influences the social systems of a society. Understanding these relationships will contribute to making students technologically literate.

Problem Solving Approach—Problem solving is another major approach to teaching technology education. Problem solving has become a basic survival skill in today's society. Technology education teachers should provide an educational atmosphere in which students can gain skills in problem solving. If this is done the students' level of technological literacy will be increased. When using the problem solving approach, teachers become facilitators who provide solvable problems for the students. The technology education teacher has the opportunity to present complex concepts in the laboratory and have students verify these concepts through a problem solving style of teaching.

Integrating the Systems of Technology—The important aspect of this approach to teaching technology education is to show the students the relationship between the systems of technology. These systems (communication, construction, manufacturing and transportation) are the basis for the technical content and concepts in technology education. When designing teaching strategies, it is important to show that these systems are integrated. In the past, the traditional industrial arts teacher considered the content as an entity, and interrelationships were ignored. However, because of the complexity of technology today, the integration of these systems must be considered. A student who sees that the systems of technology are integrated will have a higher level of technological literacy.

Interpretation of Industry Approach—When teaching technology education it is important to consider an approach which *interprets industry*. Within the systems of communications, construction, manufacturing and transportation, there are many industries that produce products and provide services. Studying these technological systems and showing how they relate to industries will make the student more technologically literate.

Delivery Systems for Teaching Technology Education

Within each of the approaches previously described, the technology education teacher has at his/her disposal a number of specific delivery systems. Delivery systems were defined as specific methods used in the classroom to present content. The teacher may select one or more delivery systems. Some delivery systems are more teacher-centered while others are more student-centered. Still others involve an interaction between teacher and students or between two or more students. The delivery systems described in this yearbook include:

1. Formal Presentations and Demonstrations.
2. Group Interaction.
3. Discovery, Inquiry and Experimentation.
4. Games and Simulation.

Formal Presentations & Demonstrations—Perhaps the most widely used methods of instruction have been *Formal Presentations* (lectures) and *Demonstrations*. Although some feel that these methods must eventually give way to more action- and interaction-oriented delivery systems, others feel that they will continue to be significant in the teaching/learning process in the foreseeable future. When one understands the advantages and learns how to design formal presentations and demonstrations, he/she will be able to unleash the potentials in these types of delivery systems.

Group Interaction—Group interaction is a type of delivery system which involves a cooperative classroom structure whereby students reach their learning goals along with other students. Other types of delivery systems are structured so that teaching/learning activities allow students to learn individually or in competition with one another. These individualistic structures at times can limit social growth. Also, competitive structures encourage students to work against each other in order to achieve. Group interaction is a cooperative classroom structure where students work in pairs or small groups to seek outcomes that are beneficial to all those with whom they are involved. Group interaction results in improved achievement, socialization, accountability, creative thinking, attitudes towards subject, student interaction and self esteem.

Discovery, Inquiry and Experimentation—One of the most effective delivery systems used to present technical or social-cultural content is *Discovery, Inquiry* and *Experimentation*. These methods provide useful ways for the technology education teacher to challenge students to learn about past, present, and future aspects of technology. The discovery, inquiry and experimentation processes confront the technology education student with problem-solving and decision making tasks that enhance individual growth and development.

The discovery, inquiry and experimentation methods of instruction create an atmosphere in the classroom for individual and group interest. This delivery system is ideal in making the transition to technology-based education, or in regular teaching practices of already established technology education courses. Because technology education will continue to be in a state of transition for several years to come, it is essential for the teacher to understand how to facilitate learning for technology education. By correctly using discovery, inquiry and experimentation, the technology education teacher can provide more meaningful and essential learning experiences.

Games and Simulation—If the concepts of technology education are to be fully realized, contemporary and innovative methods must be employed. *Games* and *Simulation* are relatively new to the technology education scene. Simulation is a method where the teacher creates or replicates an industrial situation in which the students will become involved. These experiences may be created by using an electronic simulator, computer simulator or through a number of other techniques.

Gaming is somewhat similar to simulation in that a situation is set up similar to one which may happen in industry. The difference lies mainly in that gaming techniques are oriented toward social interaction while still involving the study of technology.

Both simulation and gaming can be applied to most any area of human and technological interest. These techniques require careful, thoughtful development, but provide high levels of motivation. This is because of their direct application to real problems and because of the competitiveness posed by the simulation or game related to a real-world situation or issue.

Relationship Between Approaches to Teaching Technology Education and Delivery Systems for Teaching Technology Education

There is a very direct relationship between approaches to teaching technology education and delivery systems. **Figure 2-1** on the following page shows such a relationship. Referring to this figure, note that along the left side, approaches are listed. Along the top axis each of the delivery systems is shown. When the technology teacher makes decisions about instructional strategies, he/she will be working in one or more of these blocks. For example, conceptual learning as an approach to teaching technology education can be delivered or accomplished by using formal presentations (Block 1) or any other delivery system (Block 2, 3, or 4). Also, it may be accomplished by using a combination of two or more delivery systems. The selection of the exact delivery system for each approach will depend upon the type of technology to be studied, the objectives, concepts, content, facilities available and level of the students. The challenge for the technology teacher would be to incorporate the most appropriate of the twenty-four blocks during the course of instruction.

INSTRUCTIONAL STRATEGIES FOR TECHNOLOGY EDUCATION MODEL

DELIVERY SYSTEMS / *APPROACHES*	CHAPTER 9 Formal Presentations & Demonstrations	CHAPTER 10 Cooperative Group Interaction Techniques	CHAPTER 11 Discovery, Inquiry, & Experimentation	CHAPTER 12 Games & Simulation
CHAPTER 3 Conceptual Learning Approach				
CHAPTER 4 Interdisciplinary Approach				
CHAPTER 5 Social/Cultural Approach				
CHAPTER 6 Problem Solving Approach				
CHAPTER 7 Integrating the Systems of Technology Approach				
CHAPTER 8 Interpretation of Industry Approach				

Figure 2-1: The "Approaches" to Teaching Technology Education and the "Delivery Systems" for Teaching Technology Education provide for selecting instructional strategies in one or more of the blocks shown.

LEARNING THEORY

Introduction to Learning Theory

When selecting instructional strategies, learning theory must play an important part. Many learning theories have been suggested in our field. One of the more important aspects of learning theory even today relates to John Dewey's philosophy of *learning by doing*. When teaching technology education this theory must certainly be embraced if our discipline is to remain vibrant and innovative. It is well to keep in mind, however, that the *doing* aspect of Dewey's theory involves the mental as well as the physical.

One other aspect of learning theory that parallels the approaches to teaching technology education is that of Bloom's Taxonomy. Although many preservice and inservice teachers have studied Bloom's Taxonomy, it is important for them to see how it relates to technology education. This section provides a basic review of Bloom's Taxonomy and ties it to the instructional strategies selected for teaching technology education.

Domains of Learning

Educational learning can be divided into three domains. These include the Cognitive Domain, the Affective Domain and the Psychomotor Domain (Bloom, 1956). All three domains play a significant part in teaching technology education. Cognitive learning involves the development of intellectual skills and abilities. Affective learning is involved with attitudes, feelings and values that are developed within the student. Psychomotor learning deals primarily with the development of muscular and motor skills.

Figure 2-2 shows how these three domains interrelate. In the classroom most information that is learned begins in the cognitive domain and is then transferred to the psychomotor domain and/or the affective domain. This means that if any psychomotor activity is to be done correctly, cognitive information must first be learned. Also, attitudes can be better developed in the students' minds if a solid cognitive base is learned first. 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 laboratory may assist in the development of desirable attributes in the affective domain.

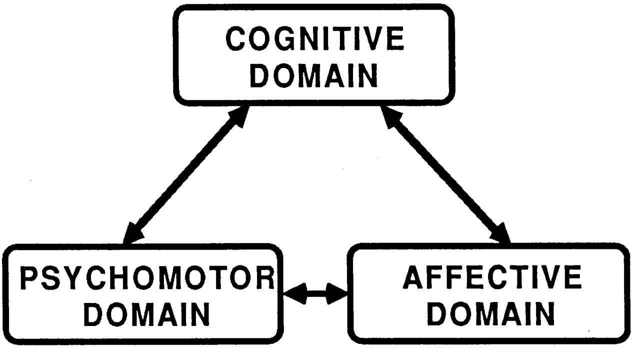

Figure 2-2: The cognitive, affective and psychomotor domains are interrelated. For example, the development of the psychomotor domain is enhanced with the development of the cognitive and affective domains.

Cognitive Domain. The cognitive domain is broken into several major levels of learning. These levels, or categories, help to build a base of information when teaching technology education. The six levels are shown in **Figure 2-3** on page 27 (Orlich, 1985). One very important part of understanding the cognitive domain is that each of the categories listed is stated as an important part of the total hierarchy. This means that the lower categories must be completed before going further up the hierarchy. These may be considered stepping stones to higher learning levels. For example, information at the knowledge level must be given before the student can move on to the comprehension level. This continues to the highest level of learning which is evaluation. The evaluation level can only be reached in technology education programs after the other five levels have been introduced.

One major emphasis when teaching technology education is to design teaching strategies that allow the student to move up the ladder as far as possible. Too often in the past, students were never encouraged to work at the higher levels of synthesis and evaluation.

The six levels of learning within the cognitive domain are:

1. *Knowledge*—knowledge is the level that emphasizes remembering, either by recall or by recognition. It is considered the lowest level of learning. However, it is necessary to work at this level in order to get to the comprehension level. An example of information taught at this lowest level would be to

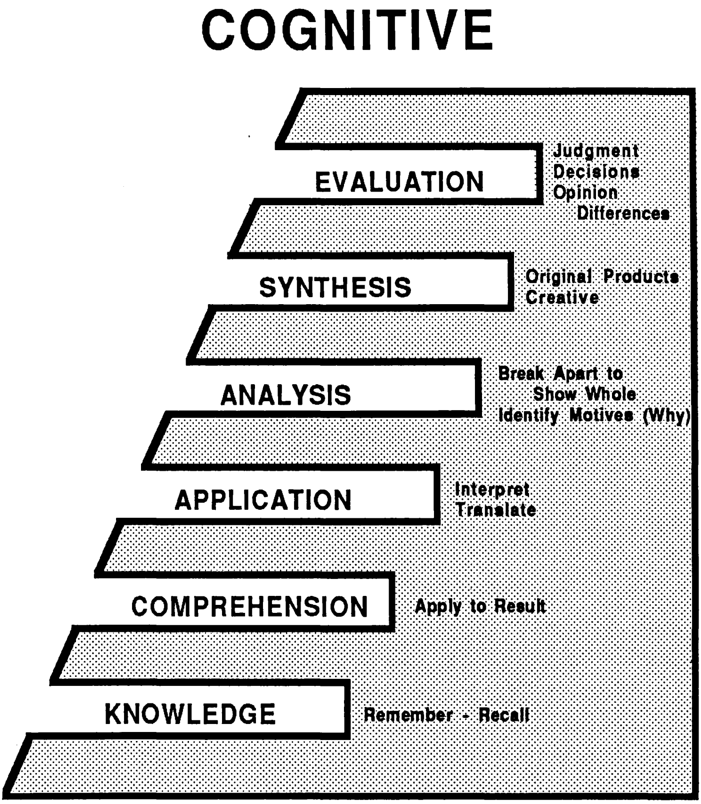

Figure 2-3: The cognitive domain has several levels of learning. Knowledge is the lowest and evaluation is the highest level.

have the students memorize the four major types of transportation: terrestrial, marine, space and atmospheric.

2. *Comprehension*—the comprehension level of learning emphasizes the transfer of information into more understandable forms. It includes restating the material in words other than those learned at the knowledge level. For example, if the students were asked to define in their own words what terrestrial, marine, space and atmospheric forms of transportation are, they would be working at the comprehension level.
3. *Application*—the third level, application, is defined as applying or using information to arrive at a solution to a problem. Typically, the student is required to bring together information learned at the knowledge and comprehension levels to solve the problem. An example of a teaching situation at this level would be to ask the students to work word problems. If the student had to calculate how much energy is used in a residential dwelling, he/she would be working at the application level. Note

that the formulas and definitions must have been learned at the knowledge and comprehension levels first.

4. *Analysis*—analysis 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 are put together to see or understand the whole. This level, again, is dependent upon what has been learned at the three previous levels. An example at this level would be to ask the students to discuss the major differences between various nuclear reactors. In order to accomplish this the students must disect the nuclear systems in a reactor and compare them.
5. *Synthesis*—synthesis entails the creative meshing of elements. In order to work at the synthesis level, the individual must have acquired knowledge, gained comprehension, made application and worked at the analysis level. An example in the technology classroom would be to have the students design and create a mass transportation system that would meet a special need. The project would require learning at all previous levels of this domain before an adequate project could be creatively developed.
6. *Evaluation*—the evaluation level involves making decisions on controversial topics and substantiating these decisions with sound reason. Examples would be for the students to evaluate technological issues such as nuclear energy or acid rain. Other evaluation examples would be to evaluate the use of robots in manufacturing or the impact of mass communications on society.

Note that *learning by doing* can easily occur at the higher levels of learning. The technology teacher should have as his/her goal the selection of instructional strategies that create learning situations which will bring the students up to the higher levels of learning.

There is also a close relationship between these levels of learning and the approaches to teaching technology education. For example, the social/cultural teaching approach relates closely to the evaluation level in the cognitive domain (making judgments about technology and its social impact). Problem solving, as an approach to teaching technology education, relates very closely to the analysis level (identifying the parts of a problem to determine a solution).

Affective Domain

The affective domain involves the development of students' feelings, attitudes, values and emotions. In today's society it becomes very important to have students develop sound values and attitudes concerning technology and its impact on society. The purpose in the affective domain is not to teach or transfer attitudes to the students, but to have them develop their own attitudes, values and feelings about a certain subject.

The attitudes, values and feelings can become much more justified if a sound cognitive base has first been developed. For example, one of the best teaching methods to develop good safety attitudes is to teach the cognitive information about safety. The more one learns about technology (cognitive development), the more justified the attitudes, values and emotions developed will be. For example, one objective of the technology education teacher might be to develop an attitude about energy conservation. This can be better accomplished if the teacher develops within the students a solid cognitive base of information about energy uses and availability. It should be the ultimate goal of all technology education teachers to work constantly toward the development of attitudes, values and feelings about technology in our society.

Psychomotor Domain

The psychomotor domain is concerned with the development of muscular skills and coordination. Again, there is a direct link between the cognitive domain and the psychomotor domain. The more cognitive development relating to a certain subject the better the psychomotor development. Technology education is considered general education and, therefore, the psychomotor domain should be considered as an aid in reaching cognitive and affective objectives. For example, a psychomotor activity in the area of energy utilization may be to run a dynamometer test. The actual running of the dynamometer is considered a psychomotor activity (turning the valves, reflex, etc.) However, the information gained by a dynamometer test will be used at the evaluation level of the cognitive domain (evaluating engine performance and making judgments on its condition). In this example the psychomotor activity was needed to enhance the development of the cognitive domain. Too often in traditional classrooms, the psychomotor domain is used as an end goal. When selecting instructional strategies for teaching technology education the psychomotor domain should be used as a means to an end. The end goals can either be in the cognitive or affective domains.

STUDENT NEEDS

In the past most of the instruction provided in American junior and senior high schools has been teacher-directed. This has been true in all curricula within the schools. But this cannot be accepted if we are to transmit the knowledge and skill inherent within the technology field. Teachers spoonfeeding students will not facilitate the type of learning that is needed. A gradual, but steady movement from teacher-directed to student-directed learning will be more effective in bringing about the desired results. If we allow students the opportunity to determine what they are to learn and how they are to learn it they will become more highly motivated, independent learners capable of solving modern day problems. Solutions to modern day technological problems are, of course, a major goal of technology education. To help understand student-directed learning, student needs are an important aspect. This part deals specifically with the development of student needs.

Motivation and Student Needs

There is a direct link between how students learn and their level of motivation in the classroom. If a student's needs are met, motivation for learning is increased. The technology education teacher has the responsibility to identify student needs and to set up situations that help meet these needs.

To begin, the student's motivation for learning is tied directly to his/her needs. Student needs in the classroom are conditions which reflect and are associated with feelings of well being. Whatever these conditions of well being are, they tend to direct the student's motivational patterns. **Figure 2-4** shows the characteristics of a person who has both positive and negative feelings in the technology education classroom. When positive feelings are developed, feelings of security result. The student has a tendency to turn outward and be motivated. In addition the student is at ease, satisfied and peaceful. However, if negative feelings are produced in the classroom the result is usually anxiety, turning inward and a reduced level of motivation.

Types of Student Needs—there are several types of needs that students have. These needs can be divided into two major areas. These include *sustenance* and *influence* as shown in **Figure 2-5** (Gore/Schwaller, 1977).

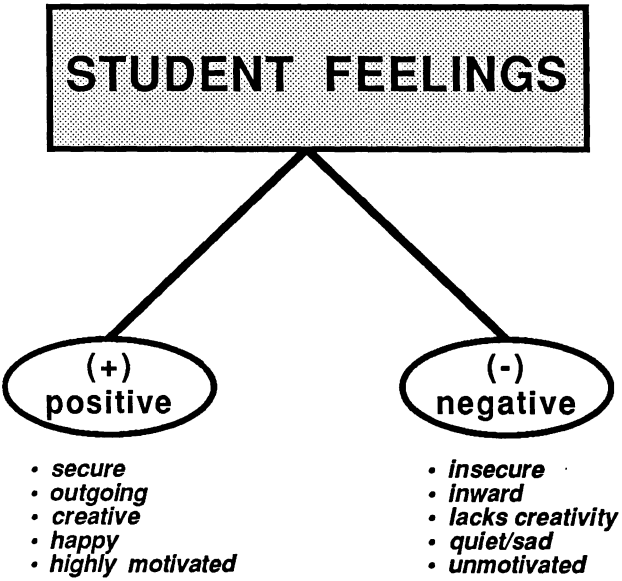

Figure 2-4: Students that develop positive feelings are generally more outgoing and show higher motivation than students that have negative feelings.

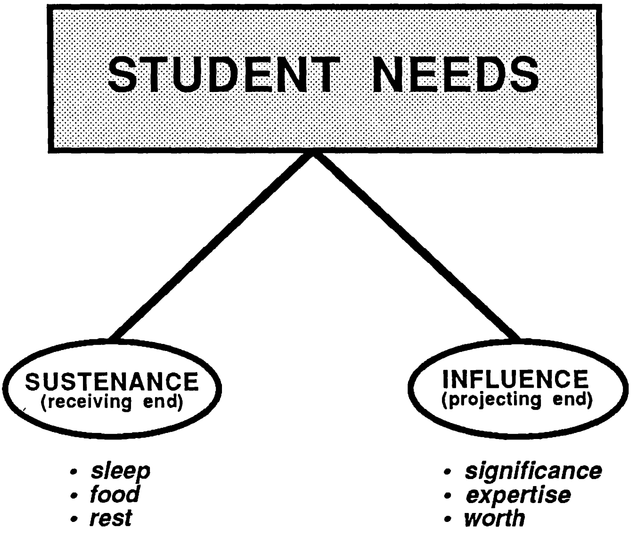

Figure 2-5: Student needs can be divided into two major types. These include sustenance and influence.

Sustenance is defined as conditions that are essential to a person's own maintenance and well being. The student is typically on the receiving end. These needs include such things as sleep, food, rest, comfort, etc. If these needs are not met the student may develop negative feelings in the classroom. These negative feelings will have a direct and negative impact on his/her motivational patterns. However, if these needs are being met, outwardness, positive attitudes and increased motivation occur.

One additional need in the sustenance area is approval. Each of the students in a classroom must feel a part of a group and must feel group approval. The approval must be from one's peers and not subordinates. Again, when a student feels part of the group, positive feelings result and motivation increases. On the other hand, if a student feels disapproval from his or her peers, then the result is negative and motivation may be reduced.

The technology education teacher should constantly be aware of students' needs in this area. In order to do this the teacher must, of course, know the students very well. This becomes a very strong prerequisite to understanding the sustenance needs of each student in the technology classroom.

A second area of student needs is called *influence*. Influence is defined as developing control toward other people. The student typically is on the projecting end and not on the receiving end, as in sustenance. All students have a need for influence in their lives. Words that parallel influence include status, significance, position, expertise, importance, worth, valuable contribution, competence and comfort giving. For example, if a student does not feel competent or important, negative feelings usually result. If the student has position, importance, expertise and status, positive feelings result. The technology education teacher can have a direct control of a person's influence needs. For example, if a student answers a question wrong and the teacher belittles the student, negative feelings may result. On the other hand, if the teacher can make the student feel important, worthwhile and able to make a valuable contribution, positive feelings are the result. Again, when positive feelings occur the student develops increased motivation, is outward and has security.

Student Values and Needs—Each student in the classroom is different and has a different set of values and attitudes. Values may be thought of as setting priorities upon those needs which are most important. Thus, if each student sets a different priority on needs, each student will have a different set of values. For example, certain students may have a high priority on status and worth, while other students may place a higher priority on being approved by their peers. It is important to note that the technology teacher has the responsibility in the classroom of identifying these needs and setting up conditions that help students meet their needs. If this is done effectively, there will be an increase in the motivation of the students.

SUMMARY

Chapter Two, entitled *Introduction to Instructional Strategies*, has introduced several terms that are important for the remainder of this yearbook. Instructional strategies include all the elements necessary in the teaching/learning process. Instructional strategies include determined by the content as well as the philosophy of the technology educator.

Instructional strategies can be subdivided into "approaches" and "delivery systems" used to teach technology education. Approaches (related to the goals of technology education) are broad styles of teaching while delivery systems are specific ways in which content can be delivered. There are several approaches used to teach technology education. These are the conceptual learning approach, interdisciplinary approach, social/cultural approach, problem solving approach, integrating the systems of technology approach and the interpretation of industry approach. Delivery systems include formal presentations, group interaction, discovery, inquiry and experimentation and games and simulation.

Learning theory is also a part of instructional strategies. Bloom's Taxonomy explains how learning can occur in the cognitive, affective and psychomotor domains. The cognitive domain is also subdivided into several levels of learning. These are knowledge, comprehension, application, analysis, synthesis and evaluation.

Student motivation is enhanced by studying the needs of students. Student needs are conditions which reflect and are associated with feelings of well being. Students can have both positive and negative feelings depending upon whether or not needs have been met. There are also two major categories of student needs. Both sustenance (conditions essential to one's maintenance) and influence (developing control toward other people) needs must be met in order to develop positive feelings and thus higher levels of motivation in the classroom.

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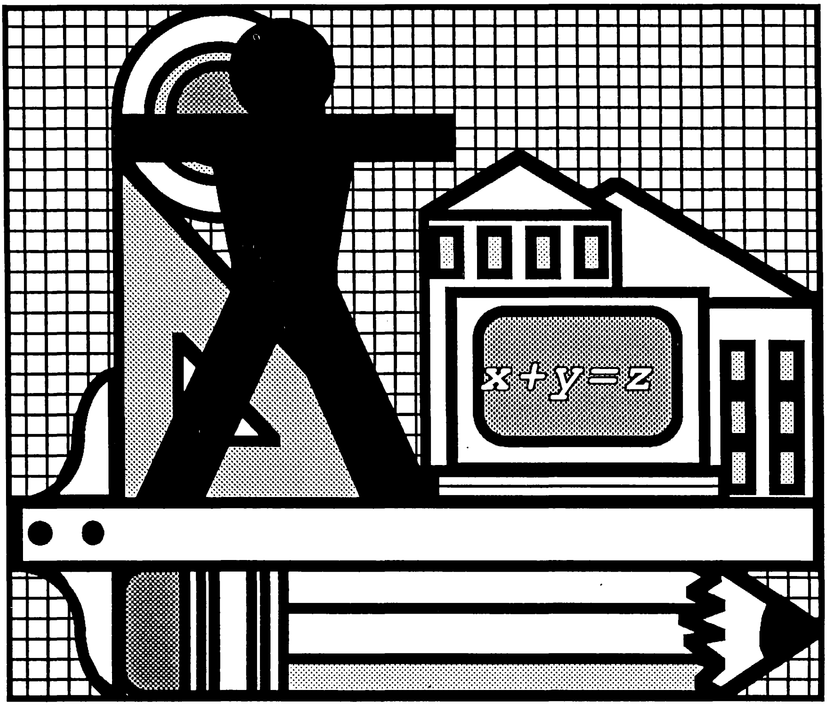
SECTION 2:



APPROACHES
To Teaching
Technology Education

SECTION TWO

Approaches to Teaching Technology Education

The content of technology education can be approached and thus taught from several vantage points. These vantage points are related to the goals of teaching technology education. Section Two is divided into six chapters. Each chapter is designed to define and describe a specific approach to teaching technology education.

Chapter Three, Conceptual Learning Approach, looks carefully at the definitions of concepts used in technology education and how one might go about teaching concepts in the technology education classroom.

Chapter Four, Interdisciplinary Approach, discusses the importance of involving other disciplines when teaching technology education.

Chapter Five, Social/Cultural Approach, looks at the need to study how present day technology affects our technological society.

Chapter Six, Problem Solving Approach, investigates the importance and need to develop problem solving skills to help make students more technologically literate.

Chapter Seven, Integrating the Systems of Technology Approach, suggests that in order to teach technology education successfully, the systems of communication, construction, manufacturing and transportation must be interrelated in the classroom and laboratory.

Chapter Eight, Interpretation of Industry Approach, discusses the need for and the importance of teaching technology education by interpreting the structure of industry and its practices.

Conceptual Learning Approach

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This chapter discusses conceptual learning. To be more accurate it is a statement about one person's (the author's) concept of conceptual learning. This chapter includes definitions, components and several complete examples of conceptual learning. Even though the reader may invest an inordinate amount of time studying this chapter, he/she will not leave it with a mental image of conceptual learning which is the same as the author's. However, through the experience of reading this chapter the reader will come to a *similar* mental image of conceptual learning.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Define the term "concept."
2. Describe how a concept is developed.
3. Explain why conceptual understandings are of value.
4. Compare conceptual understandings to fact-specific understandings.
5. Explain why concept peripheral knowledge is important to conceptual understandings.
6. List five concepts usually taught in school.
7. List ten concepts usually taught by life's random experiences.
8. Identify the critical factors in successfully teaching a concept.

Definition of a Concept

A *similar* mental image of something not strictly specified in quantitative (engineering) terms is the best that can be expected. Conceptual learning as a concept is *abstract* compared to a concept like Modulus of Elasticity (Young's Modulus) but for a technology educator to be effective he/she must know both concepts. Abstract concepts are like fingerprints in that each is a fingerprint but each is different in its minute detail. Abstract concepts are like snowflakes in that each is called a snowflake but in actual configuration each one is unique. So achieving *similar* mental images is the best that can be done when communicating an abstract concept.

In the preceding paragraphs the author has referred to "mental image(s)" several times. There are several nice terms in our languages which are synonymous with "mental image" such as idea, big picture, mental picture, big idea, mental perception, mental construct, psychological construct, psychological image and psychological picture. By this time the reader may be thinking that a concept is a mental image; if so, the reader is right.

"Mental image(s)," or a synonym thereof, has been used considerably in the preceding paragraphs. This might give a clue as to another feature of a concept. A concept is best established due to a *variety of exposures* or experiences. The greater the number of common exposures or experiences in forming a concept the closer will be the common image.

To illustrate this point about a concept being best established due to a variety of exposures or experiences, consider the concept of an elephant. The author cannot illustrate with anything much more physical than an elephant. And most are about equally unfamiliar with this concept since elephants do not roam around wild on the North American continent.

Most readers have had some exposure to the concept of elephant. In the *New Webster's Vest Pocket Dictionary* it says that the word is a noun and that the thing is a "huge animal" (1961, p. 77). The author has had some exposure to huge animals. He encountered huge animals in Alaska. The huge animals were grizzly bears. If this definition of elephant were his only exposure he would form a mental image of an elephant as being a huge animal with a stubby nose, hump back, long hair and the claws, power and mentality to disembowel anything currently walking on two or four legs.

We know this mental image to be inaccurate. We also have a more accurate mental image of an elephant due to a variety of exposures such as trips to the circus and zoo, public displays of elephants, billboard ads, representations of the symbol of the Republican party and nature shows on television. So from a variety of exposures most know elephants to be "huge animals" but rather than having stubby noses they have snouts that hang down to the ground and swing to and fro when limp. Or this anterior prolongation can be used like a flexible robot arm to *do* a variety of interesting things from picking up a peanut to skidding a massive teak log. Through a variety of exposures to elephants most also know that they appear to be hairless, their skin is wrinkled (regardless of age), they have tails, big ears rather than small and whatever the things on their toes are called, they are definitely *not* claws.

It seems safe to assume that most people have had an adequate number and variation of exposures to elephants to have formed a similar concept, definitely a concept different from a grizzly bear. But in review, the reason most have a similar concept is that they have had a variety of similar exposures which have given rise to that mental image or psychological construct.

Another important consideration of a concept is that it is a mental composite of information provided during the variety of exposures. There may well be some old African or East Indian urban craft person(s) who have built thousands of elephant leg tables. These are people who have dealt with elephant legs in most intimate ways and yet know little of the rest of the animal. They may think that the upper animal is like a cow or an ox or a rhinoceros or hippopotamus or even a grizzly bear. For a concept to be accurately formed it must be *set apart* from the many individual experiences that contribute to the formation of the concept. The concept is a melding of the many individual exposures that contribute to its formation. It is independent of the many individual exposures or experiences that caused its development.

The next requirement of a concept is that it be *retrievable* by the person who developed it and also something that can be *communicated* to others. Situations frequently retrieve a concept.

Sensing that a large animal is passing by at a leisurely pace and feeling the ground shake may be a situation that would stimulate the mental image of an elephant. Having to skid a two ton log of teak uphill without access to mechanization may be a situation that would bring out the mental image of elephant. Needing to feed a very large family on a very small budget may evoke the mental image of elephant.

To communicate the mental image of elephant to others requires a word or other symbol, sign or signal. In the communication process, if the transmitter is good at imitating the sound of an elephant and the receiver is capable of accurately interpreting that sound, the concept of elephant will be communicated. More commonly the concept will be transmitted and received using words or other symbols such as E-L-E-P-H-A-N-T.

Because most prefer not to deal intentionally in nonsense there is a final feature to the definition of a concept. It must *have application*. This mental image must have value in its potential function, its ability to serve some useful purpose. An elephant has all sorts of useful applications. Similarly, the next time the reader goes for a ride in a modern jetliner, look out and watch the wings flex; that will bring to mind the concept of Modulus of Elasticity.

Thus, the preceding paragraphs have indicated that a concept is a mental image which is developed due to a variety of exposures, but is a composite of those individual experiences; it is retrieved by a situation, symbol or signal and it has application.

Value of Conceptual Understandings

Concepts are the resources that allow rational powers to be effectively and efficiently productive. Effectiveness is *doing the right things* (Drucker, 1977, p. 40). This means applying the correct resources in the correct ways. Efficiency is *doing things right* (p. 40). This means achieving objectives using minimum resources.

Concepts provide unity out of variety, simplicity out of complexity. Concepts provide for efficient methods of organizing information. In many cases concepts allow common bodies of information to be modeled into easily perceived graphic forms.

Consider the example in the manufacturing area shown in **Figure 3-1**. The potential for profitability over the life cycle of a product is a concept that can be modeled as shown in the figure. This is an inclusive or generic model of the concept of placing a product (or service) in the market with consideration to the central intent of American industry and profit. This model, obviously, provides no opportunity for quantitative analysis but is the concept by which a product can be quantitatively tracked for the profit established.

Recall that one of the features of a concept is that it must have application. Most concepts are interrelated and because of this, to apply a concept usually requires peripheral knowledge. This peripheral knowledge and the ability to transfer it is one of the most important features of the teaching-learning process.

Technology education activities can provide exposure to concepts, but to develop real understandings of the interrelationships between concepts and applicable peripheral knowledge usually requires additional experiences as well. In the teaching of airline pilots, for example, the concepts of flight can be taught in a classroom but this will not assure that the student pilot will extend his/her final approach to land with

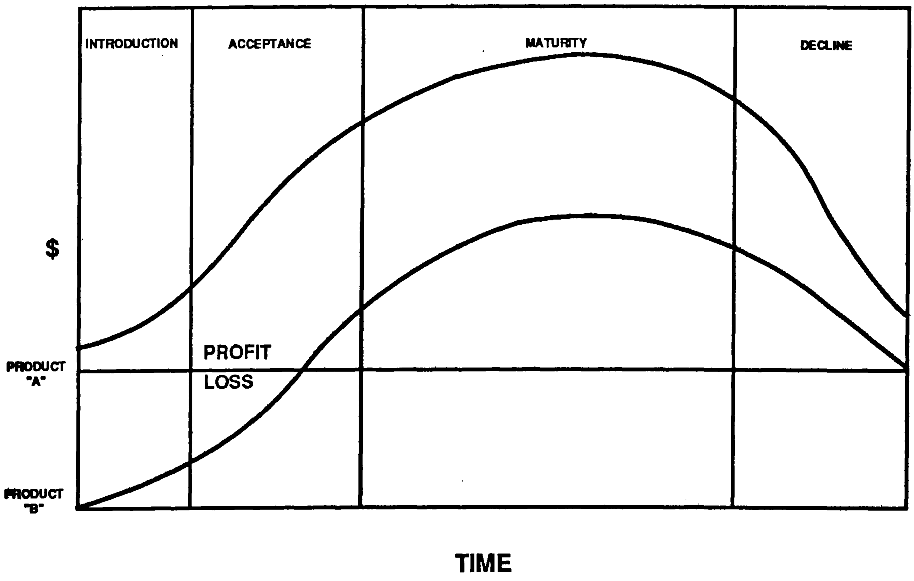

Figure 3-1: The Product Life Cycle and Profit/Loss Profile of any two products. This chart shows how a concept can be modeled.

throttle rather than stick. To assure that this is done properly takes supervised practice. This development of demonstrated competence is very important since extending the glide with throttle usually leads to a satisfactory landing, whereas extending the glide with the stick usually results in a crash.

In the case of the concept of the profitability of a product over its life cycle, as in **Figure 3-1**, a learner of the concept as modeled will not be competent in its application without some peripheral knowledge (experience). The student of this concept must know that there will be an initial loss upon introducing a product to the marketplace. This is due to research and development and screening costs, an expensive innovation cycle, fixed production costs, high initial costs of selling and other start-up and introduction costs.

The student must also know that a product life cycle which is in whole or in part projected can be influenced by unexpected environmental occurrences or by the application of resources that will influence the product's behavior in the marketplace. Firms are unable, for example, to wholly anticipate the activities of their competition. If firms lose some competition the period of product maturity may extend. If, as an auto producer, the sector is in a decline cycle in fuel efficient autos and the price of fuel increases, the decline may be reversed. A company may choose to influence the cycle at a stage of decline by coming out with the *new and improved* version or by investing added promotional resources into the declining product. To be a successful marketing person and competently use this concept of the profitability and life cycle of a product requires these peripheral understandings and many more. Time increases the complexities of this field and others.

From the past to the present, conceptual organization of information has become increasingly important due to augmentation and increasing complexity. Complex areas of information, with multiple concepts and interrelationships between concepts in differing combinations, constitute variables which are the bodies of information most applicable to conceptual organization.

All indications are that the future will bring ever expanding bodies of interrelated information. This condition will continue to prompt the need for conceptual organization to make information manageable, transferable and learnable.

Concepts of Universal Application

This chapter has thus far developed the definition of a concept and addressed the need to manage and transmit information by conceptual organization. It is time to take a look at a few concepts of universal application and then some more specific ones.

Time is a concept about which most have a similar perception. In manufacturing it is a very important resource and translates quite directly to money. In other aspects of life it takes the form of meal time, study time, play time, bed time, summer time, winter time, time of war, time of peace.

Money is a concept with which all are familiar, although some have more than others. All have a mental image of money developed due to a variety of exposures and are more likely to think and act in terms of what it does rather than what it is. People think of it when certain stimuli occur and it has obvious applications.

Justice is that concept which prompts a society to maintain a system of jurisprudence to administer a body of laws fairly. Though most recognize that it is a system open to error, it provides reasonable assurance of impartial treatment under the law. To some the concept of justice is in the interpretation of the law. For example, the author serves on a board which deals with industries in state prisons. He finds inmates very diligently studying law as related to their incarceration with the intent of finding an interpretation or law that will provide them freedom. However, inmates are little concerned about the fairness or unfairness of industries in prisons competing with industries outside of prisons.

Freedom is a concept that most hold dear. Those with a similar set of exposures have a similar mental image of freedom as a concept. And there is no doubt that the applications of freedom have provided Americans great benefits individually and as a nation.

These are examples of a few important concepts of universal application and ones that, though developed without structured academic intent, interact with others and provide the ability to deal with the world around us. Those working in the manufacturing industries deal with a concept daily which is a good example of the extensive interaction of formally and informally acquired concepts. This concept is the environment of industry in this society. As an institution and as individual firms and practicing managers within that institution, practitioners must constantly interact with the elements of that environment. The best illustration of this concept was generated by the American Industry Project and is revised in **Figure 3-2** (American Industry Project, 1967, p. 3). This concept is a very applicable instrument illustrating the dynamic sphere of influences acting on the institution of industry. This active, always changing atmosphere is the environment of industry. This is the structure of the ambiency within which management decisions are made.

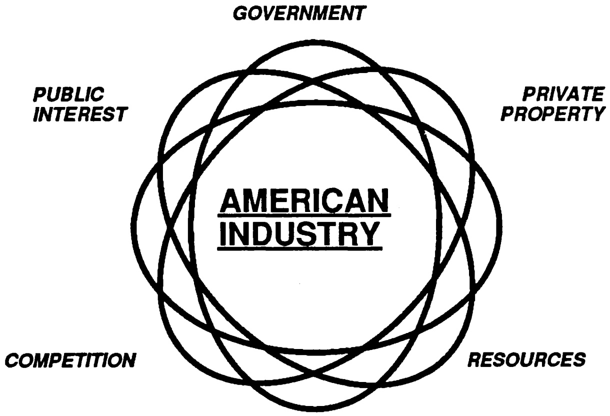

Figure 3-2: The American Industry Project is modeled after the concept of how industry functions within an environment.

In spite of the relative freedom of American enterprise one must function daily with a consideration to industry's relationship with the *Government.* If food is produced the FDA (Food and Drug Administration) must be involved. If in the communication business, one must deal with the FCC (Federal Communications Commission). Most deal with OSHA (Occupational Safety and Health Administration) and the EPA (Environmental Protection Agency). All Americans deal with the IRS (Internal Revenue Service). These are just a few examples of the billions of dollars of annual effort which represents the influence of Government upon industry.

Public Interest is that massive yet delicate circumstance that can cause a company or an entire sector of industry to flourish or fail. In a way, the environment of industry is like a neighborhood. Each individual business, each sector and, in fact, the entire institution of industry must be a good neighbor. Current news at any time is filled with the expressions of pride and joy of welcoming new or expanding industry to town or the wailing of malcontents over nuclear energy or chemical disposal or weapons production. Public interest is a strong force bearing upon industry.

The element of *Private Property* constitutes a primary difference between this relatively open and free system of enterprise and the system of a planned economy. Individuals privately own their physical plant, their transportation, and their primary and secondary supplies and materials in this system. Individuals have exclusive commercial right to their new ideas and creations. Individuals even own the land on which they do business. That is an impressive thing when one thinks about it. Without this right of private property people would have no incentive to drive on in pursuit of their dreams while at the same time building an economy second to none on this earth. The element of private property has a very physical and a very important influence on industry.

Competition is that environmental force that keeps industry lean and healthy. Its source is both internal and external; its restraints and benefits flow to both provider and consumer. Competition keeps the consumer from being abused by unreasonable prices while assuring reasonable quality, but at the same time precludes the ultimate in quality due to associated high costs and prices. For the producer of goods and services, competition is a constant threat but also provides opportunities and the ability to associate formally and to deal mutually with the other elements of the environment to the benefit of that sector. The adverse influence of government, for example, would be much more severe without advocate organizations representing sectors of industry.

Resources are the constant concern of industrial practitioners. The ability to manage is evaluated by the ratio of costs to benefits (return on investment). Costs are the resources that are used such as time, facility, money, people, good will, material, equipment, supplies, tooling and energy. These are the wherewithal by which industry accomplishes objectives. The availability of resources is very important as a part of the environment of industry.

So goes the development of another concept, the environment of American industry. It seems obvious that this concept is a melding of peripheral knowledge and other concepts developed both formally and through life's random experiences.

Concept Examples in Technology Education

Communication is in itself a concept, yet one that is organizable into a number of component concepts. As is frequently the case, the method of conceptually organizing a body of related information is dependent upon need. The Chairman of the Board of a large corporation has need to learn certain concepts to be effective on the job. A line foreman in one of the corporation's steel production plants needs to learn certain concepts to be effective on the job. The two sets of needs are substantially different and the actual conceptual content applied will be different; however the structure of the concept may be quite similar. It is in this fact that concepts become *efficiency tools* in a technological setting.

The concept of communication can be used as an example. Like the elephant, the concept of communication has conceptual parts. These parts are: source, vehicle, method, receiver, interpretation, interference and feedback.

Assume that the chairman is communicating the need for an investment tax credit on new equipment and the foreman is communicating the need to keep the flow rate uniform on the continuous casting machines.

In each case the *source* of communication is the chairman and foreman but each knows that the need to communicate must be real. The chairman has been informed by the corporate Vice-President for Finance that a tax credit is essential to allow for equipment modernization and, in fact, survival. The foreman has a surface oxygen analysis from the metallurgist which indicates a five percent material loss in mill scale due to irregular flow at the tundishes which is admitting ambient air into the molds. (A tundish is an intermediate pouring or routing vessel between production furnace and the continuous steel forming process.) In each case the source is clear on the importance and accuracy of the message to be communicated.

What *vehicle* to use is the next part of this concept. The chairman proceeds by writing a news release and preparing and rehearsing some points to be presented verbally. The foreman calculates the loss in bonus pay for his/her people due to the excessive mill scale.

The next component of this concept is the *method* of transmitting. The chairman calls a friend who is the Business and Industry Editor for the largest newspaper in the city and dispatches a courier to deliver to the editor the prepared news release. Both federal senators and the congressman who is a member of the House Ways and Means Committee are then called. Appointments are made to meet with each of these people. The chairman meets with each of them independently and presents the information that has been prepared.

The foreman calls a focus group meeting of all of the crews, shows them the oxygen analysis and shows them a diagram of how the air is entering the molds. The foreman then tells the crews how much bonus money they are losing as a result of this problem.

Each of the subjects considers the points of view of the *receivers* of the messages. The editor wants some hard copy from which to write. The senators and congressman are accustomed to verbal transactions. The crews in the plant can understand the technical explanations for the oxidation problem; and when put in terms of lost bonus wages, they recognize its importance.

An important fact about communication is that the meanings depend a lot on the people receiving the message. Other than in very precise quantitative (engineering) specifications, the *interpretation* of a communication is somewhat different by each receiver. That is why, in establishing a rationale for conceptual learning, it was written that most will come to a *similar* mental image of a concept. The chairman and the foreman in this scenario prepared their messages with knowledge of the audiences (receivers) and how those messages would be interpreted.

Another important fact about communication is that there will be *interference*. The editor will want to change some things in the news release and may change its meaning. The senators and congressman may have gotten phone calls during the meetings with the chairman. Or they may have had re-election or other matters on their minds when the chairman was explaining the importance of the tax credit. The foreman may have had to be heard over noise in the plant, it may have been too hot or the lighting on his charts may have been poor.

A final important part of the concept of communication is *feedback*. Feedback is always available. No doubt the chairman received feedback as to how much editing would be done on the news release after talking to the editor on the phone. This could have come from what the editor said, how it was said, what was said, or what was not said. The foreman could "read" the reaction of the crew to what was being presented. In each of these cases the ultimate feedback will be in results. If legislation is successfully introduced and passed to provide tax incentives in the form of credits on new production equipment, the chairman communicated. If the excessive surface oxidation is corrected, the foreman communicated. In content these cases are different; in concept they are similar. Within this example is a typical display of the versatility and efficiency of conceptual learning and application.

This concept of *communication* is especially important to a teacher of technology education because teaching is communicating. A teacher can do something of value and can communicate the concepts of that skill to others so they too become skillful. In review, the concept of communication is composed of the source, vehicle, method, receiver, interpretation, interference and feedback.

Process Engineering, as part of manufacturing, is substantially different from communication in its technological applications but it too lends itself well to conceptual organization and learning. Process Engineering is the scientific application of physical activities in the transformation of materials. Process Engineering is usually a function of manufacturing; however, in its broadest interpretation it can include the manipulation, growth and development of plants and animals in the production of food and fiber. It can also include processes of extraction as in logging and mining.

As with many broad concepts, to reach a physical (technical) application level of taxonomy requires that one get down into its component concepts. In this case, one will pass from processes to conditioning processes to mechanical cutting processes, an example with which many are familiar.

Mechanical cutting involves processing a shape change by physically contacting the work piece material with an edged tool. To accomplish this process requires knowledge of a number of component concepts and peripheral information. To demonstrate the concept of cutting with an edged tool a few of these component concepts and technical considerations follow:

1. the tool is a wedge.
2. the tool advances shear force.

3. a shear may occur or a chip be formed.
4. net part size is a consideration.
5. net shape and internal cutting are considerations. Smoothly curved and blind channels cannot be drilled in a work piece.
6. friction and heat must be considered.
7. longitudinal, tangential and radial forces can act on a tool.
8. mechanical cutting requires movement with adequate force to overcome the resistance of the material being cut.
9. tool can advance into work, work into tool or a movement may be a combination.
10. movement can be straight or curved line and on any or all axes.
11. tool must have rake and relief (clearance).
12. chip removal must be accommodated.
13. combinations of rake and clearance determine geometry of cutting lip (edge). Keen edge can ease cut but is fragile; blunt edge is more force intensive but durable.
14. machinability (mechanical cutting) does not assume good surface finish but rather refers to overall economy of the process.
15. surface finish is affected by depth of cut, rate of feed cutting speed, tool condition, rigidity of set-up, cutting fluids, structure of the work piece material and tool shape.
16. tool failure can be caused by improper tool shape, loss of hardness, breaking down of cutting edge, geometry change due to loading or normal wear.
17. tool must as be hard as or harder than the material being processed, economical, resist softening at elevated temperatures, have low coefficient of friction and be resistant to abrasion.
18. cutting fluids can be used to reduce temperatures, flush chips, reduce friction, improve surface finish, increase tool life, reduce power requirements and/or reduce corrosion.
19. there must be rigidity of set-up.
20. holding devices can be mechanical, vacuum or magnetic.
21. jigs hold work, are not attached to machine, guide cutting tool, produce uniform parts, increase output, are quick and positive loading and unloading.
22. fixtures hold work, are attached to machine, do not guide tool, are particularly strong and rigid, produce uniform parts, increase output, are quick and positive loading and unloading.

In this quick trip through the concept of mechanical cutting it should have been obvious that this information related to the concept of mechanical cutting with a prepared edged tool such as turning, drilling, milling, sawing or reaming. A similar structure with component concepts can be organized for other cutting such as abrasive cutting using random cutting edges; and in turn for all of the functional activities of process engineering. Thus, as the complexity of a field increases, the need to organize its content conceptually becomes correspondingly more important.

Procurement is another example in technology education of a concept of manufacturing. The jargon that is applied to the activities of procurement varies with time and the type of manufacturing being managed. The concept is always closely associated with inventory management and current terms in vogue are "just in time" (JIT), "material requirements planning" (MRP_1 and MRP_2), "production activity control," "capacity management," "master planning" and "computer aided process planning" (CAPP). The terms change like fashion but the concept remains the same: satisfying the requirements of production with the right thing, at the right price, at the right place and at the right time.

Procurement is frequently treated inadequately in an academic setting. This procedure treats the concept inadequately because it does not bring the learner to the point of application which, as discussed earlier, is an important feature of learning a concept.

This position of the procurement concept usually presented in classes can be referred to as the Order Size-Cost Relationship and is modeled in **Figure 3-3** on the following page.

Figure 3-3 demonstrates the relationship between order costs on a per unit basis and inventory carrying costs. The procedure as described is best applied to materials and supplies.

Order costs, or the costs of procurement, involve such activities as:

1. identification of needs.
2. specification of needs.
3. requisition writing.
4. communication, requisitioner to purchasing agent and purchasing agent to vendor.
5. evaluation of alternate sources of supply.
6. soliciting bids or negotiating with vendors.
7. issuing purchase orders.
8. follow-up communication of purchasing agent to vendor and purchasing agent to requisitioner.

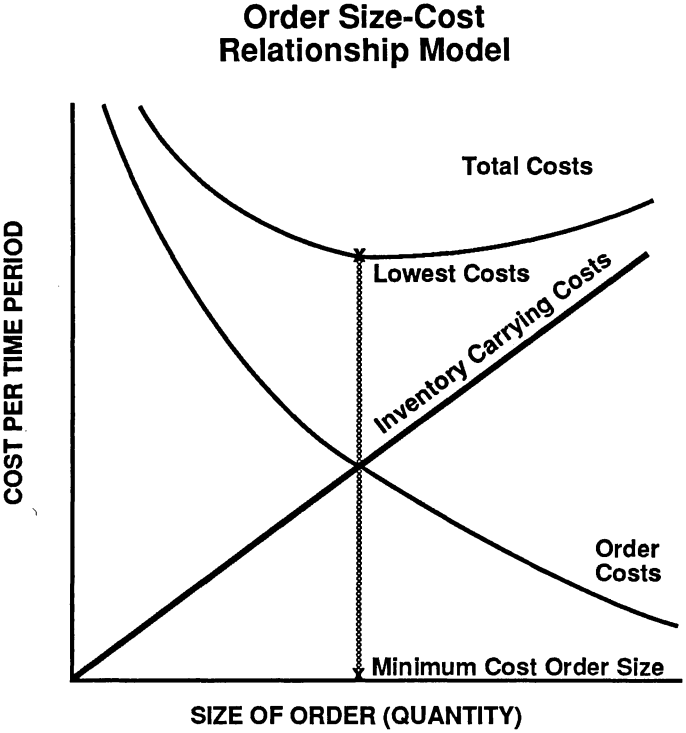

Figure 3-3: This chart shows that for certain order costs and certain inventory carrying costs a lowest cost and thus best quantity to order can be determined. However, there are many other variables that need to be considered. As these are considered, the concept of procurement moves toward application.

9. evaluation of vendor performance.
10. transacting receiving reports.
11. maintaining records.

Inventory carrying costs include:

1. record keeping.
2. inventory material handling.
3. deterioration.
4. damage.
5. obsolescence.
6. pilferage.

7. storage facility costs such as property taxes, utility cost, maintenance, depreciation, facility insurance.
8. security.
9. inventory taxes.
10. inventory insurance.
11. interest on borrowed money represented by inventory.
12. opportunity cost of money represented by inventory.

The total cost line in this model demonstrates the location of an infinite number of plots of the Y axis (mathematical) accumulations of the two cost quantities involved. The low point of the cost line is the lowest cost translated to best (most economical) quantity on the X or quantity axis.

This concept of how much of something to order is neat but not complete. It does not bring the learning to a point of application. To reach that point, other peripheral information and component concepts must be considered, such as cost of material, the cost of transportation and storage capacity (not yet considered).

For instance, assume that for a quantity of steel needed in a manufacturing operation the lowest cost (and thus quantity) is 24 tons. The truck can only haul 20 tons maximum. One has storage capacity for 22 tons. One gets quantity price breaks at 18 and 36 tons. To purchase 24 tons would be a costly mistake. A good decision, assuming no other variables, is a quantity of 20 tons.

However, to complete the development of this concept other possible variables should be considered, a few of which are:

1. if the price of steel is high but falling it may be prudent to buy less.
2. if the production schedule is uncertain, buy less.
3. if the company is undercapitalized, buy less.
4. if the price is low and rising, buy more.
5. if a substitute material is being considered, buy less.
6. if quality is uncertain, buy less.
7. if vendor is distressed, force price down, then buy more.
8. if future supply is uncertain, buy more.

With this more complete set of peripheral information and component concepts, this procurement related concept approaches the point of application. And the versatility of the concept remains strong in that it can be applied to the purchase of steel or the purchase of apples.

Finance is an important part of any technological system since profit is the central industrial objective and the ultimate measure of how well technology is serving industry. A student of technology education must realize that it is not the technology itself that will sustain our society but rather the productive results of that technology. In industry the common measure of the effectiveness and efficiency of practices (technology) is *benefit over cost*, or profit. A component concept of finance which is very usable by practitioners in technology is the concept of break-even. This concept can be a versatile tool to generate performance figures with which to examine the idea of an entrepreneur or an intrepreneur. An intrepreneur is an employee who provides his or her company with a new profit center. If the projections are encouraging the graphic display of break-even can be a valuable aid in selling the idea to others. A graphic display of the concept of break-even is also a useful device for comparing projections against actual performance and charting progress, thereby providing control of the project.

Break-even is a concept within finance which demonstrates the degree of profit or loss at various levels of output. The output measured can be anything that is reasonably predictable in demand, cost and price. It can be the number of bearings output by a manufacturer or the number of beds rented by a motel.

In referring to the generic form of break-even charting illustrated as **Figure 3-4**, several statements should be made about this concept:

1. In chart form, this concept is a snapshot at a point in time, much like a balance sheet. Its inputs should be linear. Any changing condition of input should give rise to a new chart.
2. The X axis should represent 100% of output capacity as reflected by the resources provided by fixed costs.
3. The only meaningful designation of break-even is units of output.
4. The total chart is an overlay of revenue dollars upon cost dollars with other factors constant.
5. The concept assumes that similar efficiency standards are achieved through increasing accumulations of production.
6. The concept assumes that all output is immediately transformed into revenue.
7. The field should reflect only maximum output capacity and maximum revenue or cost capacity.
8. The concept is charted for a set time period. The formula for break-even follows:

$$MC = P - V_u$$

$$\text{Break-even} = \frac{FC}{MC}$$

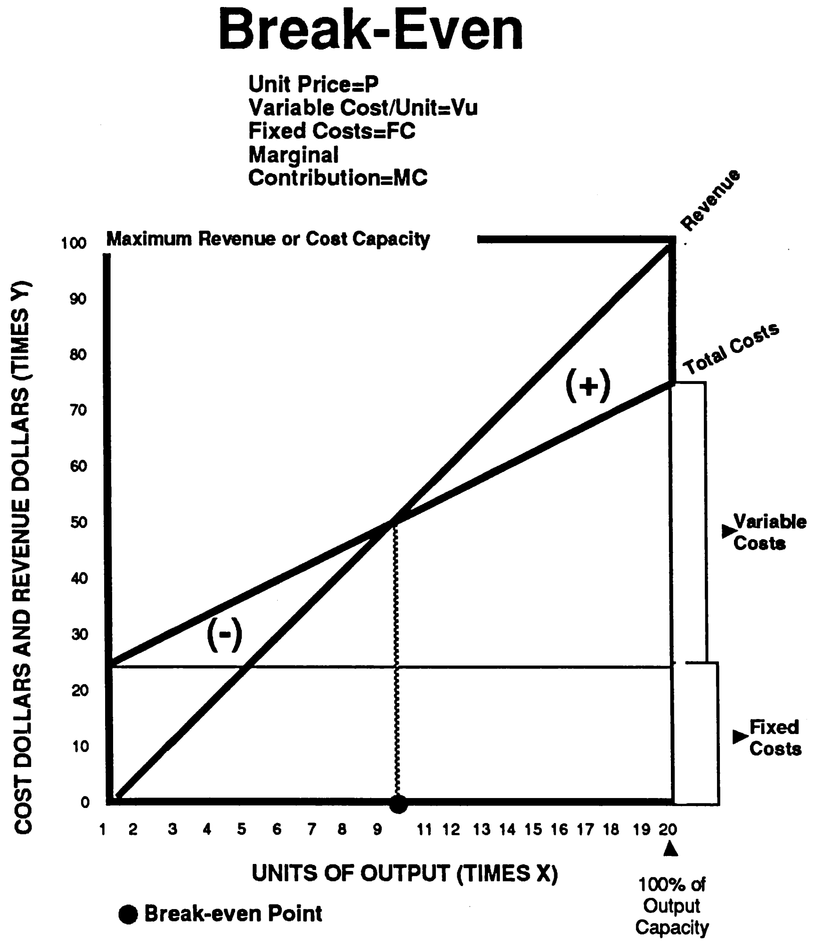

Figure 3-4: This break-even chart is a way of modeling the concepts of profit within the financial components of an industry. This concept also includes several component concepts such as variable and fixed costs, total costs, etc.

> This formula indicates that when the project has accumulated adequate individual unit contributions of the difference between the selling price and unit variable cost to cover (equal) the fixed costs, break-even is achieved.

Some observations are needed to assure that this concept has application. A fundamental consideration is that managing our technology in a way that provides break-even is managing our technology poorly. A firm which operates at break-even will survive only as an example in a classroom—not in life. Operating at break-even provides no margin for contingencies, no excess for growth, no resources for R & D (Research and Development) and no way to respond to competition. The intent and the result of efforts in technology should place each project at or near 100% output capacity for the time period.

One must be more cautious of investing in fixed costs than in variables. Variables will rise or fall with capacity to pay whereas fixed are inflexible and seriously harm the company if output falls below projections for the time period.

A plan to enjoy maximum profits from production is predicated on the terms of the break-even chart. The risk of falling short of expected output for the time period and experiencing a loss is always present. The more one misses the target production the more loss is experienced, assuming that output is on the low side of break-even. The reason for this loss is the burden of fixed costs. These loss risk observations are most important for new ventures to consider due to frequent undercapitalization. It is usually most prudent for an emerging enterprise to minimize fixed costs and divert lean capital resources to variables.

This analysis of the concept of break-even and its contribution in industrial technology could be continued, but the purpose here is just to highlight some examples of the need for conceptual learning as an educational approach.

SUMMARY

A concept is a mental image which is developed due to a variety of exposures as well as a composite of those individual experiences. It is retrieved by a situation, symbol or signal and it is applicable in other situations.

Because a concept is a mental image and each mind works differently, concepts with the same names are not identical from one person to another. But if the experiences giving rise to a concept are similar, then the perceptions of that concept will be similar.

Conceptual understandings are flexible and can be applied in reaching a variety of proper decisions. This is somewhat like the efficiencies that are gained in flexible manufacturing. Tooling and set-up times are substantially reduced and resources can more quickly and efficiently respond to needs. Conceptual understandings are an individual's versatile tools and equipment in any area of technology.

The use of concepts allows a person to organize what would otherwise be overwhelming volumes and varieties of information and make that information usable.

For a teacher to cause conceptual understandings to occur requires some important considerations:

1. the teacher must be a master of the concept being taught and all peripheral information.
2. the learner must encounter a variety of experiences from which to conceptualize.
3. there must be recognized application of the concept.
4. in technology education, conceptual learning usually requires more than classroom exposures and may include various laboratory activities.

Concepts are learned through structured experiences or taught by the dynamics of the way the world works. Both sources teach concepts of technology with broad application. In this respect, conceptual understandings provide opportunity for creativity; whereas fact-specific learning stifles creative instincts. What is called creativity is most often not creating from nothing but rather putting available things together in new and different combinations. To do this one must have flexible and versatile understandings with broad application—concepts.

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CHAPTER FOUR

Interdisciplinary Approach

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Technology education as a discipline in the school curriculum has the potential to incorporate and relate to many other subjects which are taught. Relating concepts from other subject matter areas to technology education is called the *interdisciplinary approach*. In this chapter, teaching with an interdisciplinary approach will be explored. Explanations of interdisciplinary approaches, advantages of interdisciplinary approaches and ideas for planning and teaching with an interdisciplinary approach will be presented.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Define disciplines, subject matter and the term interdisciplinary.
2. Give examples of interdisciplinary approaches in technology education.
3. Synthesize and evaluate the reasons for using the interdisciplinary approach.
4. Select the appropriate interdisciplinary approach for specified grade levels.
5. Evaluate the advantages and disadvantages of using the interdisciplinary approach.
6. Plan lessons and courses which incorporate interdisciplinary studies.
7. Teach lessons and courses which incorporate interdisciplinary studies.

WHAT IS AN INTERDISCIPLINARY APPROACH?

Some simple definitions are required in order to pursue a study of an interdisciplinary approach. Educators use the terms interdisciplinary, disciplines and subject matter to distinguish divisions in content for instruction. Often, these terms can be used interchangeably, but only when the concepts conveyed are interchangeable. The questions are: what are their distinguishing characteristics and what construct does the term interdisciplinary approach convey?

Disciplines and Subject Matter

In order to generate subject matter for the school curriculum, knowledge must be structured in some form. Many ways to organize knowledge have been suggested; however, one particular structure, the organization of disciplines and the related subject matter to be taught, is the most enduring method of curriculum organization.

Disciplines. Organized bodies of knowledge which are in the process of evolving are referred to as disciplines. These bodies of knowledge are in transition and are often referred to as disciplined inquiry, meaning that their organization categorizes the extent of human knowledge (Phenix, 1964). Examples of disciplines include: history, physics, psychology, biochemistry and technology. Note that these disciplines were not created at the same time. As scholars of particular disciplines codified knowledge, new forms emerged. Technology and biochemistry are relatively recent disciplines in comparison with history. They are emerging disciplines.

It is particularly important to remember that the organization of knowledge is in transition. Often, educators refer to a discipline-based curriculum as a reason to return to a traditional list of subject matter in the schools. Understanding that disciplines are in transition, being modified and created, provides the technology teacher with a basis for teaching technology education.

Subject Matter. In most cases, subject matter for instruction is drawn from the disciplines. This is a popular conception of the curriculum, but it is not universal. For example, subject matter such as history, biology, mathematics and literature are considered to be disciplined based. Traditionally, industrial arts was not considered to be a subject matter based upon a discipline. It entered the school curriculum at a time when creating subject matter based upon experience and integrating the knowledge of the disciplines was more popular (Zais, 1976). Today, technology education is evolving into a study based upon an emerging discipline—technology. Essentially, technology education has identified with the prevalent attitude concerning the curriculum, which is that education should be based upon the disciplines.

Subject matter, then, is the form in which information is organized for the purpose of instruction. This organization may or may not be based upon the disciplines. Therefore, school curricula may include subject matter which is either discipline based or selected and organized by some other conceptual scheme such as job competencies, individual needs and experience or cognitive processes (Eisner, 1979; Saylor, Alexander, & Lewis, 1981).

Interdisciplinary Approach

To a degree all subject matter (even most disciplines) is integrative. The concepts and knowledge of different disciplines are used in disciplined inquiry and teaching subject matter (Phenix, 1964). Rarely does a discipline exist and get presented as subject matter in a pure form. Teaching about technology requires knowledge from mathematics, physics, sociology, history, literature and many other disciplines.

Recognizing and integrating the knowledge of other disciplines into a technology education course is teaching with an interdisciplinary approach. This approach, however, has some leeway in the way in which it may be applied. In fact, it is often applied in a variety of ways dependent upon the context of the teaching situation. For example, an elementary school technology education program may be interdisciplinary to the extent that technology education serves the core curriculum subject matter, while at the senior high school technology education serves as the conceptual organization of a course with other disciplines reinforcing technology education content. These examples do not serve as rules.

Many variations of the interdisciplinary approach exist. An example familiar to many would be the program, "Principles of Technology" (Center for Occupational Research and Development, 1985). This course is interdisciplinary; however, its primary discipline is physics. The concepts of physics are organized as the main theme of the course and the related knowledge of mathematics and technology serves to teach physics. An early attempt at industrial arts curriculum revision, "The Richmond Plan," was the reverse of the "Principles of Technology" program. Technical activities were organized in order to teach mathematics and the disciplines related to science (Bunten, 1969). Another variation on the interdisciplinary theme was an industrial arts curriculum proposal called "The Orchestrated Systems" (Yoho, 1967). This program sought to use the laboratory to relate the knowledge of the disciplines in a synergistic form which would resemble the way in which life proceeds, without artificial discipline boundaries.

Variations on the interdisciplinary nature of a program can be characterized by the discipline or subject matter which serves to organize the content and the extent to which the discipline or subject matter permeates the curriculum organization.

WHY USE AN INTERDISCIPLINARY APPROACH?

From the preceding discussion it may seem that an interdisciplinary approach cannot be avoided. In fact, most technology teachers must and do incorporate mathematics and physics content into technology education classes. Recognizing this, though, is a minimal approach. It is the position of this chapter that teachers must not only recognize this fact but actively plan for interdisciplinary study. Fully implementing an interdisciplinary approach enhances and strengthens the study of technology education.

Nature of the School Curriculum

Throughout the existence of schools in the United States the curriculum has been evolving into a general form, incorporating the knowledge and skills which would benefit all students. This has generated a fairly standard curriculum for the elementary school and middle school, and it has brought about the comprehensive high school, an organization of secondary education which avoids the dualistic patterns of many foreign nations (Tanner & Tanner, 1975). The purpose of the comprehensive high school has been to serve as "the prototype of a democracy in which various groups must have a degree of self-consciousness as groups and yet be federated into a larger whole through the recognition of common interests and ideals" (Commission on the Reorganization of Secondary Education, 1918, p. 26).

Today we maintain comprehensive high schools. However, as the average years of educational attainment increase, we are seeing greater pressure on secondary education to synthesize the curriculum into a common pattern of courses for all students (Adler, 1982). Essentially, a standardized curriculum pattern similar to elementary and middle schools is being pushed into the secondary schools. This shift will provide opportunities for interdisciplinary approaches to teaching technology education.

Role of Technology Education

Technology education, as a discipline in the comprehensive high school, can fulfill various roles. A particular role is often distinguished by the grade or level at which technology education is taught.

Elementary School—although there are advocates for teaching technology education courses in the elementary school, this is not a widespread practice. Due to the philosophy of the elementary school curriculum and the constraints of elementary school practice, technology education is most frequently found as an interdisciplinary study which supports the core curriculum of the elementary school.

Essentially, technology education comes into play in the elementary school as activities to integrate various subjects such as science, mathematics and social studies. An example of this kind of an approach would be having students create and publish a newspaper because the language arts curriculum called for the study of newspapers and journalism. The activity of preparing, laying out and reproducing a school newspaper would be an application of the content of language arts.

Middle School—it is in the middle school that technology education generates separate courses with teachers who are specialists in the subject matter. Technology education courses at this level serve as an introduction to the subject matter, and are often integrative of the technological systems of communication, production and transportation. (For more information on this approach see Chapter Seven.) Those courses based upon a single technological system usually remain an introductory effort.

A current trend at this level of schooling is to transform the segmented junior high school into the middle school. One of the reasons for this transition is to more fully integrate subject matter. Separate subjects are often combined into blocks of subjects such as language arts and social studies. Technology education is often combined with other arts and electives such as music, physical education and home economics into a unified arts or practical arts block. With the unified arts, technology education can be taught as an interdisciplinary study.

Technology education may also be taught as a separate course with the integration of other subject matter and the cooperation of teachers from other subject matter areas. Excellent examples of integrating mathematics and science subject matter into technology education courses have been provided by Maley and his students (Maley, 1985).

Senior High School—technology education courses at this level range from introductory courses based on the technological systems to specific courses which are intensive study about segments of the technological systems. For example, a specific course about computer-aided drafting may exist as an advanced elective in relationship to communication. A course in research and development may be offered in order to allow intensive practice in R & D. R & D courses can be integrative of all of the technological systems.

Interdisciplinary study of technology education in the senior high school can be an attempt to integrate the technological systems or an attempt to integrate the knowledge of other disciplines. Various means of introducing the content of the disciplines may be employed. The technology teacher, other subject matter teachers or specialists from outside of the school may be the people responsible for identifying and teaching the related knowledge.

Advantages of Using an Interdisciplinary Approach

Teaching technology education with an interdisciplinary approach has several educational and political advantages. Although educational advantages are the priority, the advantages gained by cooperating with other teachers in the school cannot be taken lightly. Cooperation and integration of subject matter is a desirable and increasingly more prevalent goal in education.

Educational advantages of using an interdisciplinary approach center upon the desirability of providing instruction which allows students to understand the relationships within and among the disciplines. All too often the fragmented curriculum of the schools inhibits students from integrating knowledge into an applicable form. Since the laboratory based subjects of technology education are highly interdisciplinary, teachers have a prime opportunity to identify related content and to reinforce the relationships between subject matter. Technology education becomes a curriculum which allows the student to apply what has been learned in other courses. In the application of knowledge the students begin to see how subject matter is related and may begin to value the contribution to knowledge and practice made in the various disciplines.

In addition, the study of technology education relates well to the conduct of daily life and the conduct of occupational and professional life. During the course of a normal day, adults engage in hundreds of examples of the integrative application of the disciplines. Knowledge of science comes into play in the regulation of our heating and cooling systems; planning processes associated with researching and developing are employed when we plan and carry out projects at work; mathematics are employed as we ponder the differences in the prices at the grocery store; and knowledge of political science, economics and ecology enters into our decision making at the voting booth. This kind of application of knowledge occurs in the technology education laboratory. As students plan construction projects, they must consider the advantages and disadvantages of alternative heating systems, thereby applying knowledge based upon meteorology, physics, ecology, aesthetics and mathematics. An interdisciplinary approach to technology education provides the teacher with an opportunity to point out and reinforce the knowledge which contributes to technology.

As technology teachers begin to teach from an interdisciplinary perspective, they can reach out to other members of the school community for advice, help and cooperative efforts. This affords technology teachers the opportunity to establish cooperative working relationships with other teachers and to increase the awareness of technology education within the school community. Inviting other teachers to work with the technology education program is a way of breaking down the walls which separate departments and lead to "turf" problems in the schools.

IMPLEMENTING AN INTERDISCIPLINARY APPROACH

Planning and teaching an interdisciplinary approach to technology education can be challenging. The technology teacher must either take on the responsibility for planning or involve others in that process. During the planning process, identification of adequate resources and subject matter knowledge becomes a concern. Choosing appropriate content from related disciplines can be difficult without adequate preparation in subject matter. Moreover, the basic concepts of technology education should not be lost in the interdisciplinary approach. Concerns about identifying interdisciplinary content, demonstrating the relationship of the disciplines to technology education and planning interdisciplinary lessons and activities must be addressed.

Identifying Interdisciplinary Content

One of the first questions raised is: How should interdisciplinary content be identified? Technology teachers teach about a comprehensive discipline, but they are not often exposed to the depth of education and experience in disciplines related to technology education. This places the technology teacher in a position of having to identify additional resources and help.

Resources—searching for relationships to other disciplines requires the teacher to research technology education concepts and activities in greater detail. This type of research effort should lead the teacher to the library, technical experts or teachers of related subject matter.

Reading and research is a necessary step in planning curriculum. The technology teacher has a number of resources available. Journals such as *The Technology Teacher, Industrial Education* and *School Shop* provide a place to begin. Laboratory activities and accompanying information provided in these journals often include the first clues about the interdisciplinary knowledge embedded in the activity. Special features in some journals specifically mention the relationship between the topic and other disciplines. In addition, textbooks from technology education and other fields can provide information. Science textbooks, particularly from the physical sciences, are particularly useful to technology teachers.

Seeking Help—people can serve as valuable resources during the research effort. Local contacts in industry can help the teacher to identify related content. Subject matter specialists within the school community can provide guidance in identifying related content. Sharing technology education concepts and curriculum with mathematics, science, language arts and other teachers can not only help the technology teacher to identify related content, but it can also help all of the participating teachers to think about and plan cooperative activities and lessons. In addition, a subject matter specialist will be able to help the technology teacher understand the average achievement of students in relation to knowledge of the subject. This can help the technology teacher to select the particular interdisciplinary concepts to be included.

Planning Interdisciplinary Curriculum

Curriculum plans are usually communicated through outlines of concepts or through lists of goals and objectives. These formal plans are arranged in a way that allows easy communication of intentions. Prior to creating such an outline, a significant amount of time is spent synthesizing and evaluating the information which will be in that outline. A particularly useful process for identifying interdisciplinary content is the curriculum webbing. It allows the teacher to identify a concept or activity and the related information which would be needed to teach them.

Webbing is a common method of curriculum planning for elementary school education and its use has grown through an interdisciplinary approach to curriculum organization. This method can help technology teachers to identify interdisciplinary content.

Essentially, a technology teacher would begin the planning process with identifying either the concept or the activity which is to be taught. The activity or concept would be from technology education curriculum guides. For example, a production teacher in the middle school may identify a concept such as "designing a product." After identifying the concept, the information required to teach product design is identified and listed. See **Figure 4-1.** That information may include teaching about brainstorming, market surveys, rules of design, sketching and drafting techniques and other information needed to convey the concept. Note that what has been identified could still be classified as technology education information. However, note also that the more detailed the list of content, the easier it becomes to establish relationships with the content of other disciplines.

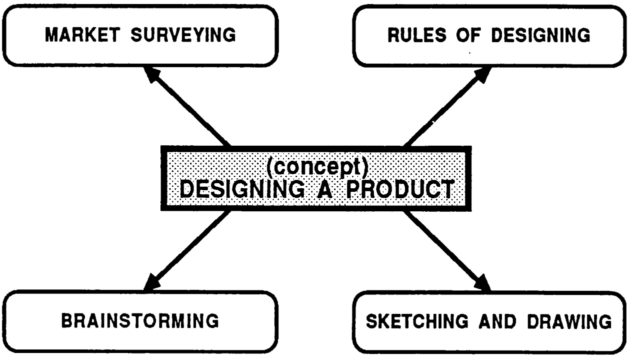

Figure 4-1: When determining what content can be taught about a certain concept (Designing a Product) in Technology Education, first identify the information required to teach the concept.

Further detail in one area, design, begins to identify knowledge associated with the subject matter of art. See **Figure 4-2.** If the rules of design are delineated further, the teacher will begin to list concepts such as balance, symmetry, form follows function, etc. At this level it becomes clearer that the information is related to art. It may also become clearer to the teacher that additional help in identifying acceptable content and practice may be needed. It is at this point that consulting an art teacher will greatly enhance the quantity and accuracy of the related content.

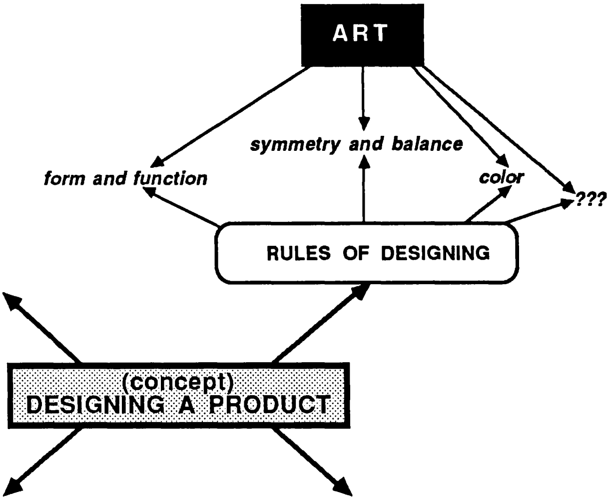

Figure 4-2: As more detailed information is produced about the concept of design, other disciplines begin to emerge. This process is called "webbing."

Each branch of the web can be developed in the same manner. See **Figure 4-3** on page 66. Differences between concepts and activities will be based upon the content and that content will lead to varying subject matters. Each segment may be taken to the most suitable subject matter specialist for additional help and suggestions.

Teaching Interdisciplinary Content

Once interdisciplinary relationships have been established and content has been identified, the curriculum plan may be turned into lessons. Several decisions will need to be made. Selecting specific content to be taught and delivery systems for teaching that content will be important.

Selecting What Will Be Taught—creating webs for every technology education concept or activity will provide technology teachers with an abundance of lesson content. In fact, there will probably be more to be taught than time allows. At this stage, the teacher must become selective. The information and lessons must fit with the abilities of the students and the general guidelines for the course. An introductory course may allow less time for detailed study of all related content, whereas an advanced course may provide the time to dwell on particular topics.

Several considerations will guide the selection of what content is to be used. Those considerations will include the ability of the students

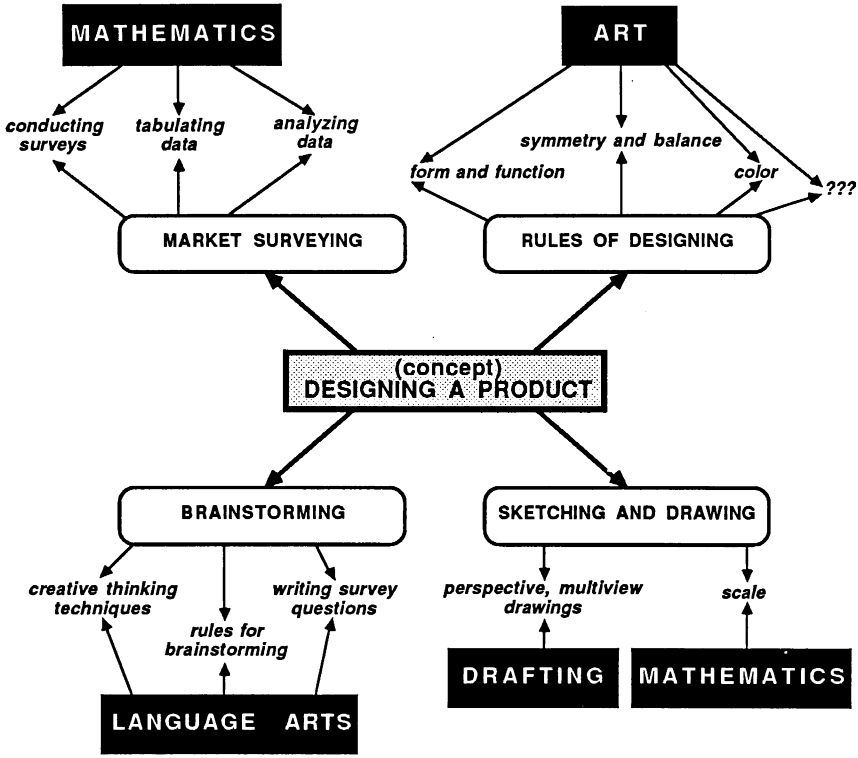

Figure 4-3: Disciplines that are related to the concept of Designing a Product include Art, Mathematics, Language Arts and Drafting.

to learn the concepts, the availability of time to teach interdisciplinary content, the resources and equipment available to the teacher to teach the content, the willingness of other subject matter teachers to assist (or teach that content) and the value of the related content to the understanding of technology.

For example, a middle school teacher who has production students for four weeks may not have the time to spend on market surveys. That subtopic and the related information about statistics may be eliminated in favor of the information related to art and design, which would be chosen because it is more valuable for middle school students. However, a technology teacher who has a production class for a year may well decide to organize the class into a business and study each phase of introducing a new product. If this class is at the senior high school level, statistics and market survey techniques may become an important part of the program. Identifying and studying the relationships between mathematics, statistics, probability and the decisions made when introducing a new product would enhance high school students' understanding of manufacturing.

Technology teachers will have to select the interdisciplinary content which best integrates with their courses based upon the constraints of their own teaching situation.

Selecting the Appropriate Instructor—the technology teacher has many delivery systems available to teach interdisciplinary content. The important point here is the decision about who will teach the interdisciplinary content.

Technology teachers may choose to be responsible for teaching the related content; on the other hand, subject matter specialists may be invited to do that. Just as deciding what to teach, the person who will teach the information will help guide the final decision.

Several types of arrangements may be created. The interdisciplinary content may be taught by the technology teacher, the subject matter teacher or a visiting specialist. The instruction may take place in the technology education classroom or laboratory, or it may be done in the other subject matter teachers' classrooms. The content may be a part of the technology education course or it may be a part of a science, language arts or mathematics course. It may even be a course which is team taught. Possibilities and variations are numerous. Innovation and creativity can help the teacher to plan.

EXAMPLES OF PLANNING INTERDISCIPLINARY CURRICULUM

Examples of planning for interdisciplinary content are included here in order to help the reader understand this chapter. An example is selected from each technological system. **Figures 4-4, 4-5** and **4-6** on the following pages are the curriculum webs of each topic. An outline follows each of them.

The curriculum webs and the outlines are basic examples only. Individual teachers will have additional content to add to each web and outline.

Related disciplines are indicated on both the webs and the outlines. Once again, the information is basic and it would be expected that individual teachers could develop different webs and outlines for the same or similar topics.

Communication

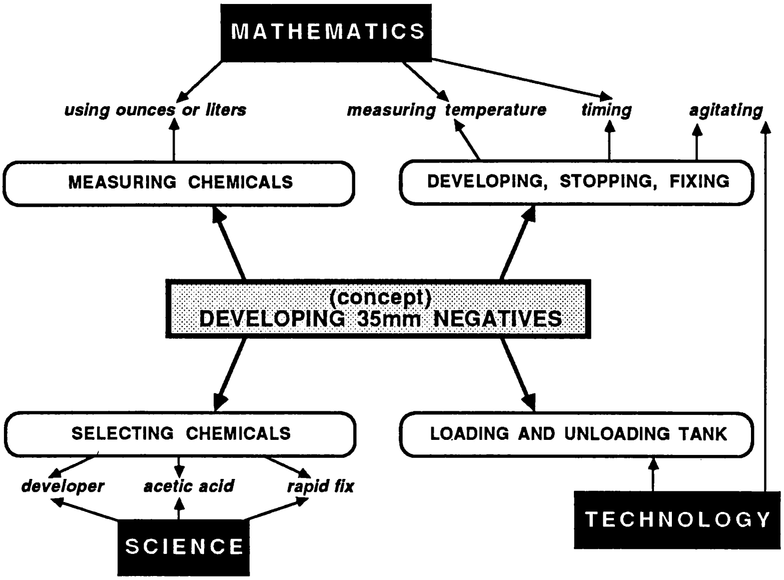

Figure 4-4: Webbing in the Communication area, Developing 35mm Negatives.

I. Developing black and white 35mm negatives
  A. Loading the developing tank (TECHNOLOGY)
  B. Selecting appropriate chemicals (SCIENCE)
    1. Developer
      a. HC 110
      b. Microdol
    2. Stop — Acetic acid
    3. Fix — Rapid fix
  C. Measuring chemicals (MATHEMATICS, SCIENCE AND TECHNOLOGY)
    1. Measurement system
      a. Ounces
      b. Milliliters
    2. Accurate use of measuring cylinders
  D. Developing, stopping, fixing (MATHEMATICS AND TECHNOLOGY)
    1. Measuring temperature
      a. Systems
        1) Fahrenheit
        2) Centigrade
      b. Reading thermometers

2. Timing
   a. Reading clocks
   b. Setting timers
   c. Selecting appropriate time based upon developer, film and temperature of chemicals
3. Agitating

E. Unloading the tank (TECHNOLOGY)

Production

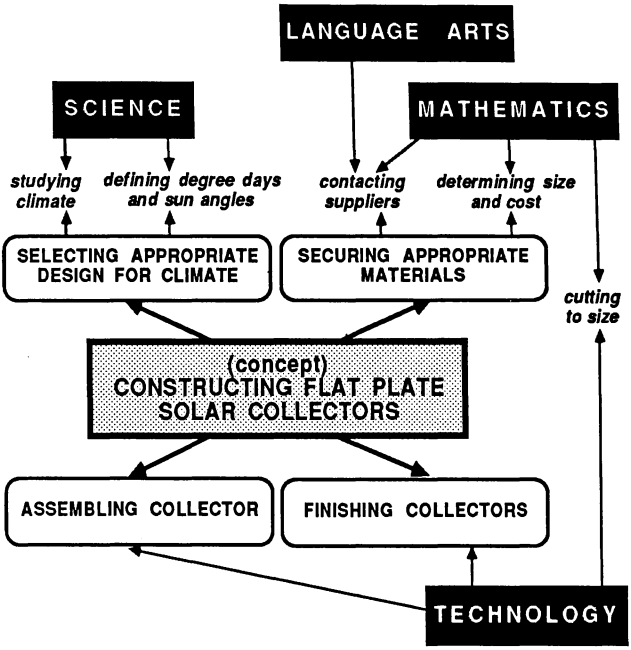

Figure 4-5: Webbing in the Production area, Constructing Flat Plate Solar Collectors.

II. Constructing flat plate solar collectors
   A. Selecting an appropriate design for the climate (SCIENCE)
      1. Studying local climate conditions
      2. Defining degree days
      3. Calculating sun angles

B. Securing appropriate materials
    1. Contacting local suppliers (LANGUAGE ARTS)
    2. Determining size and cost of materials (MATHEMATICS)
    3. Cutting materials to size (TECHNOLOGY)
C. Assembling Collectors (TECHNOLOGY)
D. Finishing Collectors (TECHNOLOGY)

Transportation

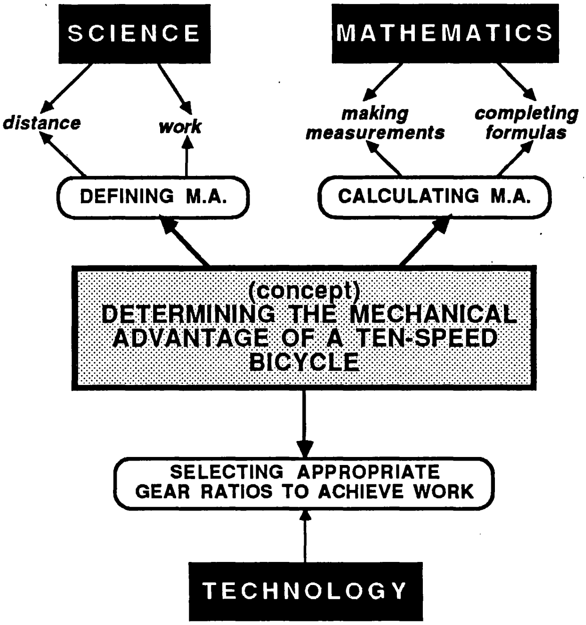

Figure 4-6: Webbing in the Transportation area, Determining the Mechanical Advantage of a Ten-Speed Bicycle.

III. Determining the mechanical advantages of a ten speed bicycle
    A. Defining mechanical advantage (SCIENCE)
        1. Work
        2. Distance
    B. Calculating mechanical advantages (MATHEMATICS)
        1. Making measurements
        2. Completing formulas (MA=pedal distance/rear wheel distance)
    C. Selecting appropriate gear ratios to achieve efficient work (TECHNOLOGY)

SUMMARY

Teaching technology education with an interdisciplinary approach has been explored by determining the nature of disciplines, discussing the uses of an interdisciplinary approach and planning ways in which to implement an interdisciplinary approach.

Disciplines as organized bodies of knowledge can be related to the study of technology education when technology is used to organize the concepts of a curriculum. Technology education as a subject matter in the school can serve to integrate the knowledge of the disciplines through technology activities. Implementing an interdisciplinary approach to technology education can be achieved through cooperative planning and instruction. Using a curriculum planning technique, such as webbing, is one way to identify interdisciplinary content which relates to technology education.

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CHAPTER FIVE

Social/Cultural Approach

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Of all the various approaches that a technology education teacher could adopt, the social/cultural approach is the most appropriate for improving the awareness of how humankind interacts with technology. It expands the technical curriculum to include both the positive and negative impacts of technology and how they affect the individual and his/her personal and professional lives. By expanding the technical knowledge base to include social/cultural impacts, students are able to increase their technological literacy level to help them deal with technology related problems and opportunities for the purpose of better decision making.

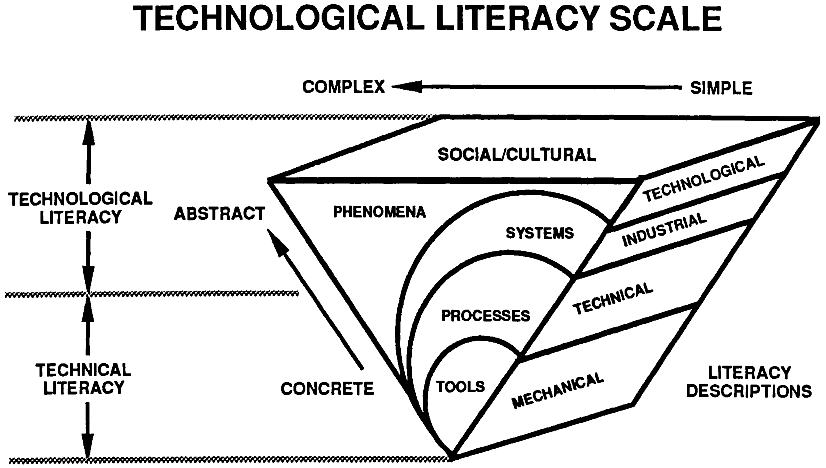

Figure 5-1: A comprehensive approach to technological literacy means teaching beyond just the technical aspects of technology.

Indeed, one of the major differences between industrial arts and technology education is a major goal of improved technological literacy. Wright (1980) presented a model that technical literacy can be expanded to technological literacy by including an understanding of technological systems, complex technological phenomena and the inherent social/cultural impacts. He maintained that it is possible for a person to become technically and/or technologically literate, but that one may not depend upon the other. This is shown in **Figure 5-1** more clearly. Ideally, technology education should have a major goal of achieving both (p. 36).

This same position is supported by the International Technology Education Association as a proposed direction for the profession illustrated in the publication, *Technology Education: A Perspective on Implementation* (1985, p. 25) and by the leadership group who authored the *Jackson's Mill Industrial Arts Curriculum Theory* (1981, p. 15). Assuming then, that the improvement of technological literacy for improved decision making capability is an accepted major goal of a technology education program, it is appropriate to turn our attention to the task of refining the instructional process to support technology education curricula.

OBJECTIVES

The approach required for teaching the social/cultural aspects of technology education is considerably different from that with which industrial arts teachers are familiar. This chapter will provide ideas on how to begin this new approach and after completing it, the reader will be able to:

1. Contrast and define the various relationships between humans and technology and the impact they have on values, norms and ethics.
2. Describe the impact that technology has on the social systems of family, government, religion, education and industry.
3. Provide a rationale for the study of technology as a part of general education.
4. Develop awareness curricula that will include the social/cultural aspects of technology for responsible decision making.
5. Demonstrate at least six methods of teaching social/cultural impacts.

6. Design action packed activities that highlight the impact of technology on humans in the areas of communication, production and transportation.
7. Evaluate the quality of instruction for technology education based upon its effectiveness in making students aware of the social/cultural implications of technology.
8. Make better decisions about the use of technology because of a better knowledge base and literacy about technological systems.
9. Become sensitive to the human condition and its relationship to good or bad use of technology.
10. Introduce a broad view of technology to students in an effort to increase their overall technological literacy level.

TECHNOLOGY AND CULTURE

The relationship of technology and culture is uniquely interdependent for all societies in the modern world. That relationship is based upon both human and technological factors and becomes more intense as the level of technology progresses. Lauda reminds us that only humans have the unique ability to pass on accumulated knowledge and culture from generation to generation (1986, p. 17). Technology has allowed humankind to adapt to the environment even though we are not necessarily (physically) well prepared for it. That knowledge base is highly technological, and its accumulation has allowed us to advance our understanding and use of technology exponentially. The rate of change associated with technological development affects both our culture and personal value systems. As we teach about the various aspects of technology, it is possible to relate technical developments with human and technological factors.

Human Factors

In our society technology is used every day at home, in public and private work places and for leisure by every age group. We take technology for granted and are usually comfortable with it until it conflicts with personal beliefs. These beliefs (called values, norms and ethics) are part of our cultural heritage and are often challenged by technological change. When in conflict, stress occurs because the impact causes change in the relationship (perceived or real) between what we believe to be good and what is possible.

For example, the question of euthanasia is raised because of our technical ability to sustain life beyond normal limits. It causes human stress because the decision making process has been complicated by new technology which may be directly in conflict with one's values, norms and ethics. This could be true for the use of nuclear power, new toxic chemicals, pollution, birth control, artificial organs and a variety of other technological developments or processes.

If we cannot resolve the conflicts between new technology and our values, norms and ethics, the stress factor may lead to avoidance in the form of a technofear or technophobe. Hellman (1976) in his book on *Technophobia* concluded that many of the people who have technofears or technophobia are victims of technological illiteracy. To them, the technological solution not only conflicts with their personal beliefs, but immobilizes their ability to deal with the problem and related stress. The result is avoidance of the problem which causes long term negative feelings about technology in general. We all know of at least one person who avoids the use of a computer. Continued resistance to the use of a computer will increase the overall resistance to new technology in general.

In *Future Shock*, Toffler (1970) makes a strong case for the importance of reference points. His thesis is simple: if we were to take people from a low technology country and place them in New York City they would suffer from cultural shock. This would happen, primarily, because they would not be able to identify with events around them, i.e., they would not have any reference points. His point is also most appropriate for a person who lives in a technological society and is technologically illiterate. Unless the basic technical reference points are provided, such a person would continue the avoidance syndrome and feel stress and conflict with his/her personal value system.

Technological Factors

The most significant technological factor is our ability to accumulate knowledge, store it on a computer, retrieve it for analysis and make decisions about alternative solutions. The computer provides unprecedented access to a larger knowledge base in science and technology and that has fueled technological growth. It is most difficult to keep up with this accelerated change; however, as educators we need to be able to describe it conceptually (see Chapter Three). That can be done if we visualize the technological systems and the general characteristics of technique.

In *The Technological Society*, Ellul (1964) described technology as having some natural characteristics of which we should be aware and think about as we try to describe the phenomenon of technique. The characteristics are as follows:

1. *Automatism*—when the most efficient technology becomes so obvious that it is self-sustaining.
2. *Self-Augmentation*—when a new technical form appears, it makes possible and conditions a number of other technologies to follow.
3. *Monism*—all the separate technologies can be collected in one larger technology and the whole has similar features regardless of its speciality.
4. *Universalism*—technology is used by all peoples of the world regardless of their civilizational development.
5. *Autonomy*—since technology seeks the most efficient means, to be truly technological is to be truly self-directing.

The five aforementioned characteristics give us a clue as to how we are affected by advancing technology. It is easy to get "caught up" in technology because the system tends to be inexhaustible. Yet, to describe or explain such phenomena in a classroom becomes much more difficult. That is why the systems approach has so much value in technology education. When we study the technological systems of communication, production and transportation we are able to put it in human (social/cultural) terms as humankind the communicator, producer and transporter.

Each system is (as Ellul has pointed out) separate yet uniquely alike in many ways. The separate technologies are different and individual, yet have common uses across the system. For example, if we study production technology, there are many tools and processes that are used to produce a product or service. Yet, production cannot occur without the use of communication and transportation technology. The vice versa is also true; indeed, all systems are both independent and interdependent. (Chapter Seven discusses these systems and their relationship further.) These are technological factors that students should understand if they are to be truly technologically literate.

TECHNOLOGY AND SOCIAL SYSTEMS

The impact of technology on the various social systems affects our lives on a daily basis. In fact, social systems are the primary focus when teaching technology education from a social/cultural approach. Both the positive and negative aspects of technology can be discussed in context with the impact on the five basic societal institutions. The institutions are shown on the diagram in **Figure 5-2.**

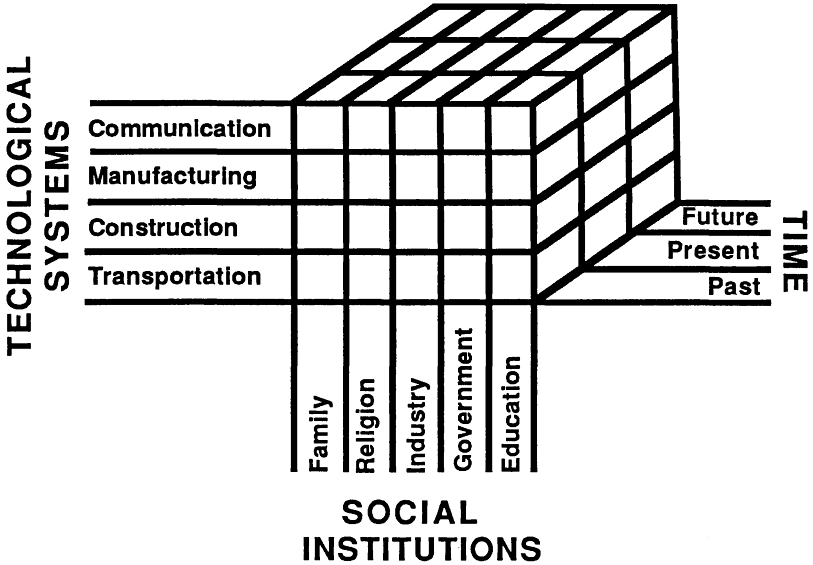

Figure 5-2: A number of social/cultural activities can demonstrate the relationship of technical and social interface over time.

Some examples of how technology affects the social systems are provided below. It should be pointed out that there are far too many relationships that could be used and covered in this chapter. Once one gets an idea of the types of impact that can be taught in technology education, it is just a matter of selecting appropriate examples to enhance the curriculum.

Family

The family is affected by technology and has adapted to accommodate the change. Because of technology we tend to be more transient, require more services, have more leisure time, enjoy better health and live longer. These trends cause strain on the family value system by decentralizing the family unit, extending the length of adolescence, materializing personal values and providing more independent flexibility. Some of these impacts are good and some are bad. As a technology teacher, the material should be presented in a neutral manner and the value judgments should be individualized based upon personal reference points.

Government

Government is a human organization created to meet the needs of a society. Its ability to meet needs is increased by technology in such areas as national defense, environmental controls, social services, police and fire protection and economic policies on a world-wide basis. Perhaps the most significant impacts on government have been the computer and television. Both technologies have allowed better communications and more effective action for social problems. When a television program highlights a toxic waste site in a residential area, government responds. When the government reduces the prime rate, industry responds. These and many other relationships are based upon modern technology and have a direct effect on the social institution of government and on people.

Religion

The impact of technology on the church has been significant. Televised missionary TV specials uniquely show how the religious community has taken advantage of the new technology to provide more effective communication.

Thirty years ago the parents of a sixteen-year-old girl did not have to cope with the technological choice of birth control. The "pill" has challenged the family and its religious values and norms more than any other form of technology except that of euthanasia.

Even the theory dispute of evolution versus creation is tied closely to science and technology and can't avoid the impact it makes.

In a period of time when the population is much more mobile, the Church continues to search out new ways to stabilize its congregation and provide religious and social value leadership, while maintaining the flexibility needed to meet the needs of its people.

Education

As educators we are keenly aware of the influence that technology has had on education. Teaching aids, video productions and self-learning software programs have enhanced the educational process. The educational plant is a better facility in which to teach, and the advancements in transportation have provided a broader mix of students through regionalization.

Yet, the technology used in traditional school shops represents a post World War II capability with little computerization control. It is difficult to imagine that elementary schools have students working with computers every day, and many industrial arts programs are void of computer use.

The impact of television on school age children has challenged education to deliver modern and relevant education. For the technology education teacher, the challenge is very urgent because students know that there is a world of robotics, electronics, automation and communication that they could be studying. Parents will tend to advise students not to take woodworking or sheet metal courses but rather to take physics and computer science courses, if we do not offer a more attractive technologically oriented program.

Industry

The impact of technology on industry has been dramatic, particularly in the past fifteen years. The economic decline and loss of productivity has allowed other technological nations to capture the lead as producers in the world economy. As a nation, much of our industry has been working overtime to catch up technologically. One of the keys seems to be in microprocessor technology and quality automation processes. This trend will continue and indicators show a positive advance in this area.

But there are related problems of energy usage, toxic waste, environmental restrictions and consumer demands. A technology education program could help students understand both the positive and negative effects of technology and how we may cope with them in the future.

PURPOSE OF TEACHING SOCIAL/CULTURAL IMPACTS

In addition to helping students gain competencies in a variety of technical areas, teachers need to provide opportunities for them to evaluate whether the technology is appropriate and necessary. This can be achieved by providing a broader view of technical means, reviewing the responsibilities of the technologist, and helping the students clarify their views for responsible decision making.

A Broadened View of Technical Means

Students can explore technical and technological impacts by extrapolating historical data of major technical developments in the past. The opportunity to study history within the context of technology lends added value to the importance of technical means. Visual time lines with dates and pictures of the developments can be effectively used as student group projects. Another approach is to have students build working models, provide demonstrations and write reports on how the technology works and the impact it had during its era.

Technological assessment and forecasting techniques can also be used by students to broaden their views on modern technical developments. In this approach, students can select a technology, research its impacts at the library, write to companies for materials and try to forecast the future of the development. In the school laboratory with a *research and development* theme, each student or groups of students could build prototypes to try to innovate or invent new technology. Student-built robots (Wright, 1983, p. 18) have been successfully used to demonstrate this approach in the past, and the possibilities are unlimited.

Global impacts for technology can also be demonstrated in the areas of resources, satellite communications and transportation. One group of students successfully constructed a four foot diameter globe from several materials and used colored lights to show where resources are located and where they are used. The group presented the model as a demonstration during an all school assembly. It enhanced their understanding of resources, gave them an opportunity to combine practical hands-on activity with research activity and produced a sense of pride and accomplishment during the all school presentation.

To explore the concept of human versus technology, intensive work situations, mass production of a product which utilizes a combination of hand processing, machine processing and simple automated processing can be used. This manufacturing activity will open the door for the instructor to discuss the positive and negative effects of each level of processing and how they relate to a modern industrial approach.

The point to be made about the social/cultural approach is really quite simple. To study only technical means outside the context of their impact on social and personal value systems will result in a narrow view of technology and will limit students' abilities to make more meaningful decisions as citizens who live in a technological society.

Responsibilities of the Technologist

Most of the students who elect technology education will probably become some type of technologist in the future. Some will not, but they will need to understand the role of the technologist in developing and using advanced technology. Because of that, it would be beneficial for the technology teacher to cover the roles of technologists and what they do.

The responsibilities of a technologist are very important to society and can affect one's personal well-being. A few of the issues that could be discussed in a technology education class are: code of ethics, company sensitivity to the community, research applications and environmental consequences. Whether it is a career/professional orientation or simply a description of the technological workplace, it is important for students to consider the implications of technology and work.

Personal Decision Making

One of the primary goals of general education at the secondary level is to prepare students to become responsible and contributing members of society. That is an awesome task to which technology education can make a major contribution. We can do it by:

1. Improving technological literacy.
2. Providing students with skills necessary to access and analyze technology.
3. Making students more aware of their own value systems and the relation of values to technology.
4. Providing opportunity for decision-making simulations.
5. Helping students realize that choices do exist concerning the use of technological systems.

In a democratic society we are often called upon to vote or provide input concerning technological developments at the local, state, national or possibly the international level. The better informed we are about an issue, the more opportunity we have to make an appropriate decision. Since our society is inherently technological, it is imperative that the citizenry understand the nature of technology. Technology education can play a significant role in helping students understand the impact of technology and its positive and negative factors.

In our society, the study of technology could actually be the core of a strong general education program if it were presented in a holistic and integrated manner. It has the potential to tie all the other subject areas together and present a coordinated approach to secondary education.

METHODS OF TEACHING SOCIAL/CULTURAL IMPACTS

There are several methods that can be used by the technology education teacher which will improve understanding of the relationship of technology and society. These can be implemented if the necessary resources are developed above and beyond the standard technical resources found in most modern technology education facilities. These new methods can be classified into six major groups as shown in **Figure 5-3** on page 83. They include:

1. Technology Bookshelves.
2. Impact Films and Media.
3. Ancillary Content for Lectures.
4. Student Impact Activities.
5. Selected Field Trips.
6. Special Projects and Reports.

Technology Bookshelves

The first step that a teacher can take to enhance a technology education program is to establish a technology resource center in the laboratory. The center (usually called a technology bookshelf) includes industrial and engineering journals, government resources, resource texts and R & D (Research and Development) materials.

Some schools are able to have a satellite resource center which is funded and maintained by the central library but located in the laboratory. Access to the resource materials in the laboratory ensures better usage and can help students look for important information or act as a stimulator for new ideas.

Impact Films and Media

The selection of impact films and media is outstanding today. NASA, E.P.A., United Technologies, NOVA, and many other sources will provide video tapes or films at very reasonable rates or, in some cases, even free.

Instead of buying another piece of standard technical laboratory equipment, a video player and monitor would provide a new resource that cannot be duplicated in the laboratory. This is especially true for showing impact examples of how technology influences our lives.

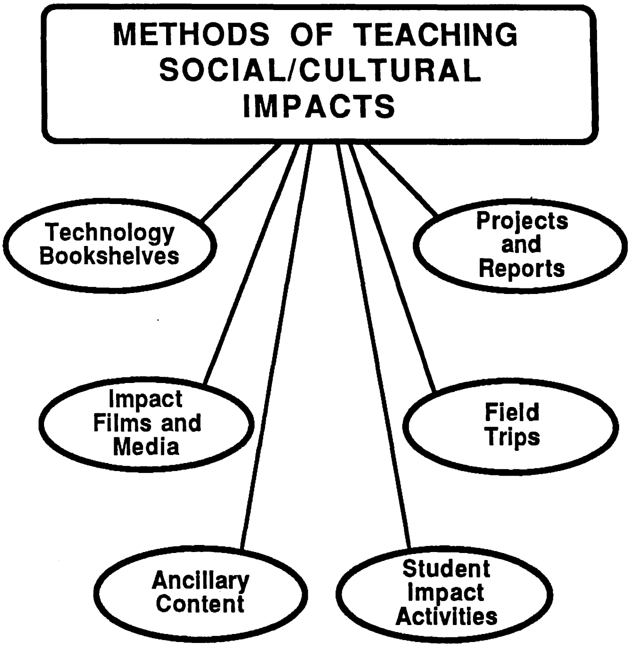

Figure 5-3: Methods (Resources) that can be used to help the technology teacher teach social and cultural impacts.

It makes for an interesting day on a Friday when everyone is tired and worn out, to have a video on how John Deere uses robots to manufacture parts in its plant, or how NASA communicates with astronauts in space.

Ancillary Content for Lectures

The literature of technology has a rich pool of information which can be classified as "tidbits" or unusual facts. By highlighting unusual events, current events, humorous facts, human profiles of great inventors and abuses or achievements in technology, the technical lecture, bulletin boards and individual conversations will become much more interesting. It is surprising how much students know about the unusual types of technological advancements, and this approach opens the door for meaningful discussion about social/cultural impacts of technology.

Student Impact Activities

A chapter could be written on this topic alone. The concept of this strategy is really quite simple. Instead of designing student activities and/or projects based upon technical processes, the teacher (or students) can select an institutional, governmental or personal "impact" and then design the activity (or project) to demonstrate it.

The aforementioned energy globe project was a good example of such a process. One of the most used activities in this area is the video camera for simulating television advertising. In this approach, students make models, prepare scripts and actually conduct advertisements before a camera. The activity generates a great deal of enthusiasm and helps students understand the influence of mass media and the wonder of electronic communication.

Many of the activities which have been used to support technology education can be found in the activities booklets produced by Davis Publications, Inc., *School Shop,* the *Technology Teacher, Tidewater Resources, Inc.* or materials available from the New York Department of Vocational Education. Teachers can develop their own materials by conducting brainstorming sessions with the class and designing projects or activities to match. In all cases, these activities or projects should still require the use of materials, tools and processes to support the idea and teach the technical part of the curriculum. This approach does not lower quality of work or difficulty level, but instead enhances the meaning of such work.

Selecting Field Trips

The typical field trip for industrial arts has usually meant a tour of a local industrial plant. That should continue, but should also be enhanced by including alternate trips to museums, environmental sites (even perhaps, the town dump or sewage treatment plant), government agencies, power plants, and if possible, summer tours of national or international interests. The point to be made is that there are several options for selecting field trips, other than a view of technical processes.

Special Projects and Reports

Industrial arts has been criticized for focusing too much on the hands-on type of learning. Although the various types of processes do require knowledge and mental application, the involvement with research and writing has been minimal. The technology teacher can provide both a hands-on and minds-on approach. The relationship between the two was discussed in Chapter Two. It can help students to improve their reading and writing skills by using technology as a motivator for them to get involved in some basic research and writing that supports the technical processes being learned in the laboratory and their inherent social/cultural impacts.

Reports may be written or oral or visual presentations that may be made allow students to demonstrate the process and provide supportive technical or social/cultural information. One group of students did a videotape project which focused on industrial pollution. While they were presenting the information on EPA regulations and the progress of the United States in recent years, the video focused on local industrial problems with a *reporter at large* format. It was extremely well done and the students were very motivated by the activity. Both the hands-on and minds-on approaches were used.

Opportunities for expanding the technical content are limited only by the imagination. Students, given the chance, are really quite innovative in their ability to think of unique ways to conduct research and present the information.

SUMMARY

Teaching which incorporates the social/cultural impacts of technology will also strengthen the technical program in technology education. It is not intended to be the only approach that would be used in instruction. But, collectively with the other approaches and delivery systems discussed in this yearbook, the technology teacher can teach technology education in unique ways that expand the traditional core of teaching about materials, tools and processes.

If technology education is to meet the needs of young people who will spend most of their lives in the 21st century, it will need to provide them with information and experiences that can meet the test of time. The systems approach with an emphasis on conceptual learning that reflects the positive and negative effects of technology has the promise of being able to meet such a challenge.

Social/Cultural Approach

Teaching from a social/cultural approach is new to many in our profession. It requires teachers to reach out beyond familiar technical content and deal with decision making processes that are human intensive but technology impacted. For the technology teacher who is a well read educator, the relationship of technology and society does not require a new expertise; it simply requires the sharing of knowledge about technological impacts with students.

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CHAPTER SIX

Problem Solving Approach

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Millions of students held their breath as the count-down proceeded. The space shuttle Challenger awaited lift off on a chilly January morning of 1986. Within moments gasps were heard as one by one they realized that the shuttle had become a death trap for the astronauts. Reports filtered in later that the cause of the disaster was a combination of weather and a poorly designed booster seal. Ironically, testimony by the technical staff indicated that they were aware of the design inadequacies with the seals, yet managers at different levels ignored repeated warnings. Certainly these managers and officials understood the benefits that technology provided; however, they failed to comprehend the magnitude of the risks involved.

The rapidly changing nature of technology brings new challenges and problems as it did in the space program. Major technological developments in transportation, communication and production require direction, control and design. The Commission on Pre-College Education in Mathematics, Science and Technology (National Science Board, 1983) addressed the effects of these technological changes in its report, *Educating Americans for the 21st Century:*

> We must return to basics, but the basics of the 21st century are not only reading, writing, and arithmetic. They include communication and higher problem solving skills, and scientific and technological literacy—the thinking tools that allow us to understand the technological world around us... Development of students' capacities for problem solving and critical thinking in all areas of learning is presented as a fundamental goal (p. v.).

The commission's report indicates that society has undergone significant change. Many of these changes and problems facing society have come about because of the advancing technology. Robert Ornstein of the Institute for the Study of Human Knowledge wrote:

> Solutions to the significant problems facing modern society demand a widespread, qualitative improvement in thinking and understanding.

> We are slowly and painfully becoming aware that such diverse contemporary challenges as energy, population, the environment, employment, health, psychological well-being of individuals and meaningful education of our youth are not being met by the mere accumulation of more data or expenditure of more time, energy, or money. . . We need a breakthrough in the quality of thinking employed both by decision-makers at all levels of society and by each of us in our daily affairs. (Costa, 1985, p. 4)

The shuttle disaster points out that individuals are needed at all levels who possess an understanding of technological systems. In addition, society needs individuals capable of finding viable solutions to a variety of challenges. These needs have prompted many leaders to suggest that education now implement methods of teaching that can enhance the problem-solving ability of young Americans. According to Costa (1985), however, "most teachers do not regularly employ methods that encourage and develop thinking in their students" (p. 5). Therefore, the technology educator has an opportunity to fill a void in the general education of students. The technology education laboratory provides a rich environment for students to develop an understanding of technology and capacity for solving technological problems. The purpose of this chapter is to provide practical suggestions for creating a problem-solving environment for youth living in a technological society.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Operationaly define problem solving.
2. Provide a rationale for including problem solving activities within the educational environment.
3. Describe and identify four qualities of a good problem solving activity.
4. Summarize the characteristics of a good problem solver.
5. Develop a plan for evaluating problem solving responses.

WHAT IS A PROBLEM?

The failed launch of the Challenger can easily be classified as a problem. A problem exists when in a given situation one encounters an obstruction in reaching one's objective. This concept of a problem is analogous to a hiker finding a deep ravine in the middle of the trail. This analogy has important implications for how problems are conceived and implemented in an educational setting.

The analogy points out three characteristics of a problem. First, it is important that the hiker recognized that the ravine presented a problem. Second, the hiker is motivated to reach the other side of the ravine, otherwise no problem exists. Third, the problem requires the hiker to utilize skill, knowledge, and understanding to explore solutions to the problem. These characteristics of a problem are significant in our approach to developing a problem solving environment. Educators must, therefore, be able to highlight problems, challenge and motivate students and then allow students to become actively engaged in seeking solutions.

WHAT IS PROBLEM SOLVING?

Problem solving is a process—a process of seeking feasible solutions to a problem. The process varies depending on the type of problem that is confronted. VanGundy (1981) classified problems on a continuum of well-structured to ill-structured as depicted in **Figure 6-1**. The most

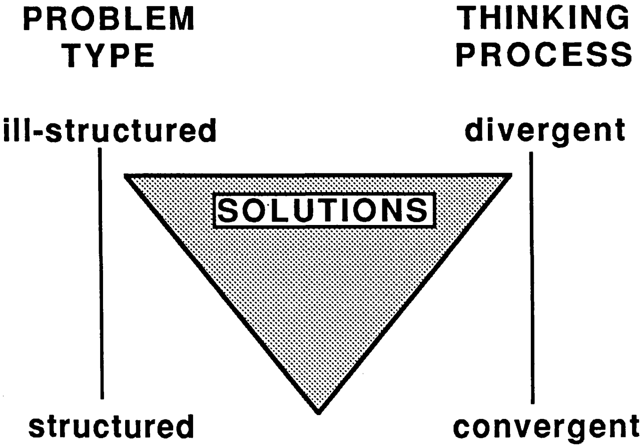

Figure 6-1: The relationship between problem types and the thinking process.

structured problems are relatively narrow in scope and usually have only one correct answer. This type of problem forces students to use *convergent thinking*. That is, they must examine the situation and arrive at the one best solution. Typically these problems are solved by using algorithms. As explained by Foulds (1983), "an algorithm for a problem is a procedure which is guaranteed to converge to a satisfactory solution to the problem" (p. 927). For example, if a person is confronted with a problem of adding two numbers, the solution is found by simply using arithmetic rules. These types of problems abound in the field of technology, particularly those related to technological processes. Students presented with problems of determining voltage, drilling speeds, or gapping a spark plug need only refer to simple rules and specifications in order to find solutions. Well structured problems need to be addressed and practiced. Once learned, however, they are no longer useful in developing the skills of a problem solver. Therefore, this chapter is directed toward higher order problem solving skills.

Semi-structured problems may have more than one correct answer and are solved by using heuristics. Heuristics are guidelines that usually lead to acceptable solutions. Most people use heuristics in their everyday life. Foulds (1983) gives the following examples:

1. Schedule the shortest job first.
2. Perform tasks in order of importance (p. 929).

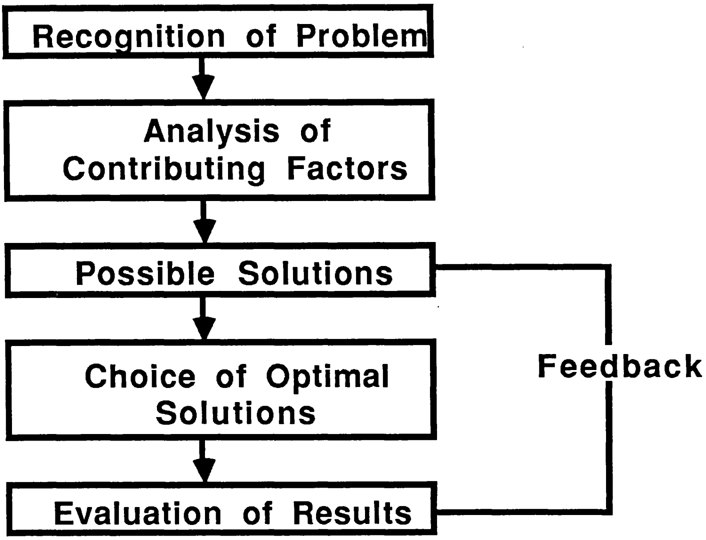

Figure 6-2: A set of heuristics.

Heuristics for problem solving are guidelines helpful in attacking semi-structured problems. A simple set is presented in **Figure 6-2** on page 90. Additional information on heuristics has been developed and presented by King (1981).

At the other end of the spectrum are ill-structured problems that have a variety of potentially correct solutions. These problems require a more divergent thinking process to provide creative solutions. For instance, developing a better means of transporting people in an urban setting is a problem with a multitude of potential solutions. This type of problem is almost never solved by looking for an algorithm nor will heuristics ensure an acceptable solution. Finding solutions to this and other similar problems requires techniques of creative problem solving. Some of the top 35 techniques as identified by VanGundy (1981) are listed in **Figure 6-3** on page 92. Many of these techniques have been explained in a useful form for technology educators by Wey (1983).

To summarize, problem solving is a process of seeking feasible solutions to a problem. Well-structured problems are solved with algorithms and convergent thinking. Heuristics are guidelines used to solve semi-structured problems. Ill-structured problems require divergent thinking and utilize creative problem solving techniques.

Problem solving has become a priority among the profession and the public. Indeed, problem solving suggests a new approach for the technology educator. The approach calls for bringing to the classroom relevant technological problems combined with appropriate problem solving techniques. In the classroom we can explain technological problems and problem solving techniques, but in the laboratory students can learn first hand how to become problem solvers.

SO WHAT HAS CHANGED?

It is important to understand how laboratory-based problem solving activities differ from traditional shop projects. One could hardly argue that the traditional shop project did not involve problem solving. In fact, many projects in woods, metals and other traditional industrial arts areas did create opportunities for problem solving because they were activity based. Consequently, the technology educator interested in problem solving is encouraged to maintain an activity based methodology. There are distinctions, however, between a program using the shop project and an activity-based problem-solving approach.

First, the problem solving involved in shop projects is used to find solutions to highly structured problems. The solutions for problems of

Redefining Problems
- Analogies
- Metaphors

Analyzing Problems
- Input-Output
- Morphological Analysis

Generating Ideas
- Brainstorming
- Attribute Listing
- Collective Notebook
- Checklists

Evaluating & Selecting Ideas
- Battelle Method
- Decision Balance Sheet

Implementing Ideas
- Potential-Problem Analysis
- Research Planning
- Diagrams

Figure 6-3: Problem solving techniques for different thinking problems.

calculating board footage, selecting a drilling speed or changing dull blades are found in reference materials. Furthermore, most of the problems occur haphazardly. On the other hand, laboratory-based problem solving is a deliberate attempt to present students with technology-based challenges. For example, a teacher might ask a group of students to solve a transportation problem in the local community by designing a model of a new transportation system. It is just such an ill-structured problem that can develop the creative problem solver.

A second distinction between the shop project and a problem solving activity lies in the fundamental outcomes of the program. Unfortunately, many teachers mistakenly judged the success of their teaching in terms of the quality of the bookcases and grandfather clocks that were produced. The goal of American education, however, has never been to produce projects. The goal has been to develop in individuals their human potential. Therefore, technology education should judge success by examining the growth of individuals and the quality of their experience in the laboratory. Specifically, technology teachers should be concerned with whether they have produced students better able to cope with the problems of a technological society.

A third distinction between the project and activity involves the content base of the curriculum. For the most part, shop projects focused on the materials and processes of industry, or crafts. With the shift to a technological base, new content was necessary. The technology educator has moved beyond the building of simple projects to involving students in activities related to finding solutions to technological problems.

The activity approach has many advantages for the technology teacher. This methodology opens up a full selection of opportunities for student experiences. In addition, problem solving activities can often be done at a very low cost or no cost at all. Lastly, these activities can make a vital contribution to the technological literacy of tomorrow's youth.

THE TECHNOLOGY TEACHER—A VITAL ROLE

The success of a program attempting to produce problem solvers is directly related to the qualities of the technology teacher and the successful creation of a problem solving environment. Among the most important qualities of a teacher is an enthusiasm for learning. This quality is essential in fostering student involvement in problems. This methodology also demands insight by the teacher into technology and its related problems.

This enthusiasm and insight must then be coupled with an understanding of the problem-solving process—including simple heuristics or problem-solving techniques. Baker and Dugger (1986) found little evidence to suggest that teachers in the past have been prepared to teach problem solving. Clearly, teacher education institutions should provide future teachers with appropriate practice in at least some of the more than seventy problem solving techniques that are now being used in business and industry. Enthusiasm, insight and skill in the use of problem-solving techniques are qualities needed to *initiate* problem solving.

Once the process is initiated the teacher takes on a new role—that of *facilitator*. This role is somewhat different in that it forces the teacher to step back and allow students time to think. Good facilitators do not provide solutions. Instead, they provide encouragement and sometimes direction in how a solution might be attained. Throughout the process the facilitator has yet another job—that of *evaluator*.

As an evaluator the technology teacher can chart the progress of students. Evidence of student progress can be made by examining at least three elements: (1) an evaluation of personal growth, (2) an evaluation of student contributions during the process and (3) an evaluation of the solution and supporting documentation (i.e. product). Observation check-sheets of personal growth can provide students with a better understanding of themselves. Process evaluation provides an indication of student involvement during each step in the process. Finally, product evaluations are indicators of the quantity and quality of the effort students put forth. A three dimensional evaluation approach is outlined below:

Personal Growth: to what degree did the student exhibit:

1. Leadership.
2. Teamwork.
3. Ability to work independently.
4. Effort.
5. Cognitive understanding.

Process Evaluation: to what degree did the student contribute to the process by:

1. Utilizing and adhering to timelines.
2. Exploring ideas.
3. Gathering resources.
4. Utilizing problem solving techniques.
5. Implementing ideas.

Product Evaluation: to what degree was the product of the activity:

1. Technically accurate.
2. Consistent with design criteria.
3. Documented regarding background.
4. Documented regarding procedures.
5. A creative solution.

WHAT MAKES A GOOD PROBLEM?

There are several characteristics of problems best suited to developing divergent thinking in the area of problem solving. The selection of problems might best be done using an INPUT/PROCESS/OUTPUT scheme as diagrammed in **Figure 6-4**. On the INPUT side it is important that problems be generated in relationship to technological systems. The pool of problems in communication, transportation and production is virtually endless. These problems can include design problems of all types, materials testing, product development or production line problems, to name a few.

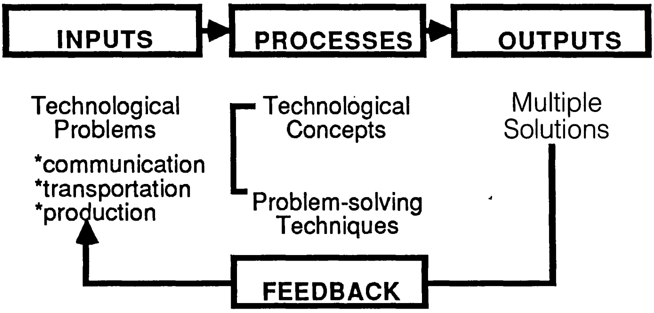

Figure 6-4: Model for the selection of good problems.

Technology teachers should then examine the PROCESS or methods by which students might arrive at solutions. The best problems for developing divergent thinking in technology education should combine two opportunities. The first should be an opportunity for students to gain practice by using problem solving techniques (including heuristics). Secondly, the problem should provide the student with an opportunity to explore and better understand identifiable technological concepts.

The last component, OUTPUT, relates to the number of solutions that are possible. The best problems for divergent thinking have multiple solutions. By examining the characteristics of the problems using the INPUT/PROCESS/OUTPUT model it is possible to create learning experiences that have great potential for generalization. That is, the skill, knowledge and understanding gained in the activity will be more transferable to new problems.

SOME STARTERS: SEMI-STRUCTURED PROBLEMS

A good example of a transportation activity is called the mouse-trap car. This problem challenges students to create a vehicle powered with a mouse trap. The instructor can further structure the problem by specifying that the designer is to attempt to maximize speed or distance. Other limitations regarding weight and size or cost may also be included in the problem. This activity can provide practice in the use of heuristics as well as developing a greater understanding of technological concepts. Students will find themselves investigating gears, guidance systems, weight to power ratios, torque, friction, lubrication and construction techniques.

Another semi-structured problem, this time in the manufacturing area, involves packaging. This activity requires individuals or teams of students to design a package that is capable of protecting a raw egg during "shipment." The challenge usually involves dropping the package containing the egg from the top of a building. Again, students can become better problem solvers by using heuristics in this activity. The technological concepts involved include such concepts as compression, tension and strength of materials.

These two examples are not new; however, they have been effective activities. For the most part, these are design activities that can be adapted with any technological system. In fact, Micklus (1984) has started what could be considered a model for developing divergent thinkers through a program called OM (formally called Olympics of the Mind). In this annual competitive event, student teams are challenged to create such technological innovations as bridge structures, unique vehicles and operational robots. In one design activity, students developed and drove a vehicle akin to the mouse trap car. The vehicle, however, was powered by one or two large springs. OM sponsors are needed in most states and provide an outstanding opportunity for the technology teacher.

The research and experimentation methodology developed by Maley (1973) also provides excellent opportunities for students to practice problem solving and to better understand technology. Students in the program identify a technological problem, investigate the problem, form hypotheses, state limitations and assumptions, devise methods for testing their hypotheses, collect data, analyze data, report findings and draw conclusions. Problems in this program vary from studying the properties of materials to testing the flight characteristics of model planes in wind tunnels.

ILL-STRUCTURED PROBLEMS

Students can also be challenged to find solutions that require even more creative solutions. For instance, how can a city's communication networks be improved? How can transportation be made more efficient? How can fresh water be practically obtained from the sea? How can vehicles be modified to extend their lives? How can a space station be manufactured in space?

It is possible using a variety of techniques to have students address such problems. Teachers can certainly challenge students to investigate background information, to generate potential solutions and to design and test models of their ideas. In some cases, the local community may be faced with ill-structured technological problems in the areas of transportation, communication and production. Teams of students could become involved in the actual solution to many of these problems. These types of technological problems will allow for practice in the use of creative problem-solving techniques that will be required in the next century.

SUMMARY

The citizens of tomorrow must possess a clear understanding of technology—its uses and implications. The technologically literate adult must also have a capacity for higher problem solving skills. The content of technology education should address technological problems and problem solving techniques through a variety of settings. The role of the technology teacher is that of initiator, facilitator and evaluator. Good problems involve the student in investigations of technological concepts along with practice in the use of problem solving techniques. Engaging students in the technological challenges of tomorrow is a must for the technology educator. The need has been established, the methodology has been proven and the time is right for including laboratory-based problem solving as a major approach to teaching technology education.

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CHAPTER SEVEN

Integrating the Systems of Technology Approach

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Integrating the systems of technology is one of the newer approaches to teaching technology education. Integrating the systems will provide the teacher with the flexibility to teach the total concept of technology and facilitate students' learning about technology as a whole, not just the individual segments or parts that make up *technology*.

Integrating the systems of technology is one of the major approaches available to the teacher that provides a means for students to learn about technology as an entity, as a whole and as a discipline. As DeVore (1980) stated, "The study of technology has been approached too frequently by studying the parts without reference to the whole" (p. 243). Actually, while teachers utilize this approach as a natural part of their teaching about technology, they typically do not realize it is happening. The purpose of this chapter is to bring about that realization.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Define the *systems* of technology.
2. Justify or rationalize the selection of the systems of communication, construction, manufacturing and transportation for a technology-based curriculum.
3. Discuss why those particular systems were selected.
4. Develop and describe the systems approach in technology.
5. Analyze the types of curriculum content similarities between the systems model and the technological systems model.
6. Identify various activities that support and expand the concept of integrating the systems.

7. Evaluate relationships between the systems of technology.
8. Develop content to reinforce the idea of increasing levels of technological literacy in students.

THE SYSTEMS OF TECHNOLOGY

During the curriculum efforts of the early 1980's, various groups struggled with the problem of identifying convenient organizers for the study of technology. Several areas were identified including communication, production, manufacturing, construction, transportation, energy and power, to name a few. In addition, several sub-areas or offshoots were identified in an apparent effort to find more descriptive terms. Among these were such titles as visual communication, graphic communication and energy utilization.

However, a logical selection of areas was agreed upon by the Jackson's Mill group (Hales and Snyder, 1981). Their selection of communication, construction, manufacturing and transportation was based on the identification of the *universal technical systems* used by humans to adapt to their environment. The principle of *human endeavor* was suggested by Ray (1980) to categorize subject matter and he identified these same areas. Logically, these four areas are systems that make up the study of technology. This same selection of systems was adopted by the International Technology Education Association's "Professional Improvement Plan" (Starkweather, 1983) and the American Council on Industrial Arts Teacher Education* yearbook entitled *Implementing Technology Education* (Jones & Wright, 1986).

Energy, or energy and power, is sometimes included as a technological system, but there is still little research or evidence to support its inclusion as one of the systems that comprise technology. The process of converting energy into power, or work, is simply one form of a production process and can be studied as such in the classroom or laboratory. Energy can also be studied as an element in each of the four systems. In addition, Ray (1980) stated that energy does not qualify as a *human endeavor* because it is an *input to all* human adaptive systems. Therefore, the study of energy does not fit into the overall scheme as one of the major divisions, or systems, within technology.

It is understandable that traditional industrial arts teachers may be uncomfortable with the four systems concept. Typically, teachers often combine energy with transportation to establish a course or area of study. However, energy can be studied as it applies to all areas within

*Name changed in March, 1986 to Council on Technology Teacher Education.

technology. Examples of this include using solar energy for construction and alternate fuel sources in transportation.

Because of the popularity of the topic and in efforts to accommodate teachers, several state curriculum guides have identified energy as a specified area of study. This selection of energy as a topic is often based on the popularity of the topic and on political reasons. Prior to 1972 (pre-energy shortage), the selection of energy as a separate topic had only limited consideration. Finally, selection of any topic based on *bandwagon* criteria defies the standard rules of curriculum development and content selection.

The systems of communication, construction, manufacturing and transportation have a strong research base and can be easily justified for the curriculum. While these were also popular topics, they were not selected simply due to their popularity.

WHY WERE THOSE PARTICULAR AREAS SELECTED?

The areas of communication, construction, manufacturing and transportation are readily identified by students as relevant in today's society to help prepare them for life in the 21st century. Selection of these systems has followed a logical, rational sequence and was based on sound curriculum design. As stated previously, it is through these four systems that humans survived by adapting to their environment and this provides a logical base for selecting these particular areas. On the other hand, the many course titles we now have in schools and universities often cause confusion. Currently there are ongoing courses named for:

1. Materials (woods, metals).
2. Processes (welding, photography).
3. Physical phenomena (electricity, power).
4. Generic "catch-all" phrases (graphic arts, metalworking, energy/power technology).

Technology education should provide a series of broad-based experiences that can address components of the student's general education program. This information, hopefully, will help the student to make sound decisions regarding additional education or training whether vocational, college preparation or other pursuits. The systems of construction, manufacturing, transportation and communication are ideal for developing courses to provide broad-based experiences and to help increase students' levels of technological literacy.

THE "SYSTEMS APPROACH" IN TECHNOLOGY

The systems approach to the study of technology provides a convenient and built-in organizer for developing curriculum (Bensen, 1980). The systems include input, process, output and feedback. The model, (see **Figure 7-1**) provides a simple and effective means for planning and developing curriculum. Developing curriculum using the systems approach with a systems model will enable teachers or curriculum developers to grasp the total concept of technology, to develop a logical and rational sequence for the courses and, most importantly, relay this information to their students in an effective manner.

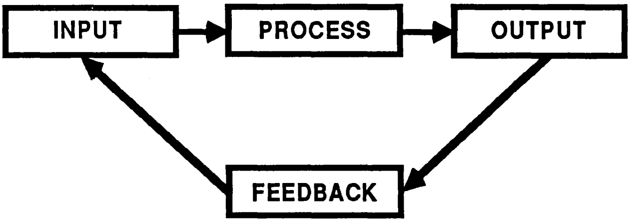

Figure 7-1: A "Systems" model provides a simple and effective means for planning and developing curriculum.

In his article on technological literacy, Wright (1980) cited that one of the primary goals of education should be the development of a "technologically literate" individual. A curriculum model was later developed by Jones (1983) to illustrate that each of the systems in the study of technology is made up of specific "levels of knowledge." These include resources, technical processes, industrial applications and technological impacts. See **Figure 7-2** on the following page.

An easy way to organize and study technology is to structure the technological systems of construction, manufacturing, transportation and communication into a systems model. To do this, replace the terms in the systems model (**Figure 7-1**) with the terms in the technological systems model (**Figure 7-2**). The results of this transition are as follows:

- Input . . . becomes . . . Resources
- Process . . . becomes . . . Technical Processes
- Output . . . becomes . . . Industrial Applications
- Feedback . . . becomes . . . Technological Impacts

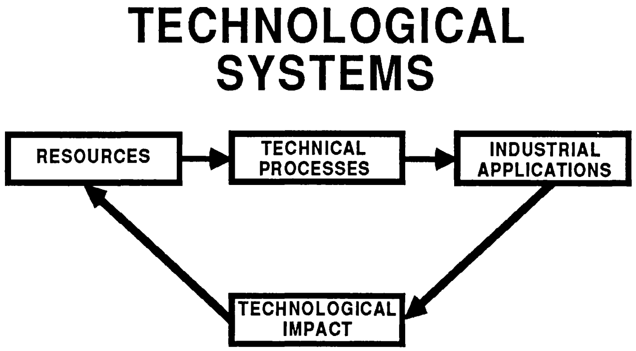

Figure 7-2: A curriculum model for technology based programs adopted for use by the Illinois Plan. (Jones, 1983)

An understanding of the four levels of the system and their interrelationships is, in fact, an understanding of the system. An understanding of the system is the attainment of the goal—technological literacy.

When one of the technological systems such as communication is studied, the resources used in communication, the technical processes in communication, the industrial applications (the relationships between communication and the other systems) and the technological impact of communication can also be studied. Obviously, this approach can be applied to the other systems of construction, transportation and manufacturing.

Using the systems approach and adopting a curriculum model for identifying content will provide a convenient and efficient method for teachers to plan and organize content (Illinois State Board, 1983). A taxonomy or scope and sequence model of content must be developed to fit into the curriculum model. Finally, the systems approach will enable students to grasp the total concept of technology, to understand the logical and rational sequence of the courses and relate this information to the world outside of school.

THE TECHNOLOGICAL SYSTEMS MODEL

Studying technology by using a technological systems model is easy, logical and simple to organize. Presenting this model to students via the systems approach will provide the students with a "road map." The students will be able to see where they are supposed to go, i.e., the objective. In addition, teachers will also have direction so they can lead students effectively.

Let's expand on the four parts of the technological systems model using communication as an example. What are *resources* in communication? They include such things as a camera in photography, a printing press in printing, a drafting table or computer for the design area or a video cassette recorder in the telecommunication area. These are resources, but they are all tools, i.e., some type of equipment. Other resources used in communication include materials. Among the material resources are film, paper, cassette tape, ink and chemistry, to name a few.

Technical processes are defined as the act of using tools to change or modify materials in some manner. Industry takes a variety of technical processes through a planned sequence and produces some type of service or product. As one of the technical processes in communication, a camera is used to expose film to light. That, in effect, changes or modifies the film. The technical process of exposure starts a chemical reaction in the film's light sensitive emulsion. The next step is to initiate another process by placing the film in a series of chemicals to develop or "process" the film to produce negatives, or positives in the case of color slides.

While studying *industrial applications*, it is actually considered from "outside" the model. When talking about communication systems, look at how communication is involved in the other systems. For example, how is communication used in construction, how is communication used in manufacturing and how is communication used in transportation? Three simple examples may help clarify the point. Communication is used in construction through the development of architectural plans. Communication is used in transportation to signal or convey information between air traffic controllers and aircraft. Communication applies to manufacturing through designing, marketing, advertising and producing product literature.

The *technological impacts* part of the model is defined as how society or the environment is influenced or affected—in our example, communication. Chapter Five in this yearbook looks closely at the process of bringing in social/cultural impacts of technology. Technological impacts are easily studied as either societal (those that affect people) or environmental (those that affect the environment). Technological impacts are either negative, positive or both. In one situation, an impact may be negative such as having several drafters lose their jobs by being replaced with one Computer-Aided Design

(CAD) operator. Impacts may also be positive such as having those same drafters being retrained to become CAD operators.

By applying the technological systems model to the other systems of construction, transportation and manufacturing, one can easily think of examples that will fit into each of the areas. Many examples of resources in manufacturing, construction or transportation will come quickly to mind. These examples will stimulate identification of technological impacts.

BRINGING IT ALL TOGETHER

Up to this point, one example of the communication system plus some additional examples have been provided to show how the other systems fit in. However, these are individual systems. Now consider the integration, or how it's all pulled together. For example, it is virtually impossible to teach manufacturing without teaching transportation, construction and communication. A "complete" job of teaching manufacturing cannot be accomplished without addressing the other three areas. A limited amount can be accomplished, or selected portions of manufacturing can be taught, but if manufacturing as a total concept (the enterprise) is to be studied completely, the other three systems must be included. However, the other three systems are probably being included now and it may not be realized.

Manufacturing and Communication

Consider communication as it relates to manufacturing. When teaching manufacturing, is product design considered and discussed? Are there sessions devoted to "thinking up" or brainstorming new product ideas? Are there opportunities for sketching or designing a totally new product or maybe redesigning a "new and improved" product, such as a frisbee? The idea of design is simply putting abstract ideas into a usable form that can be communicated to others. One of the first forms is a sketch. Sketching is a communication process, not a manufacturing process, but it is absolutely necessary as part of the total manufacturing concept.

During a manufacturing course, are students involved in a group working on marketing? Are students talking about surveys to find out who will buy the products and how or whether the products will sell? Are they talking about how to advertise? Are they advertising on radio and television? Are they considering the development of posters, static or dynamic displays or newspaper advertising? These topics are all in the communication area.

Yes, many aspects of communication must be incorporated if students are really going to understand manufacturing.

Manufacturing and Transportation

Is the study of transportation a part of the manufacturing course? Are discussions held on how rough stock is moved from the supplier to your school? It doesn't magically grow in the storeroom as some students may think. Do students study this information as part of the manufacturing course? One example of an excellent problem-solving activity is to have students locate suppliers of rough stock, determine how much material is needed and how to have it shipped to the plant. (Chapter Six in this yearbook provides more information on the problem-solving approach.)

How is rough stock transported from storage to the first machine? Is a conveyor system available? Is it carried by hand? Has consideration been given to how various parts are moved from Machine A to Machine B during the production run? These are real transportation problems. These are material handling problems that must be solved in the transportation area as part of the manufacturing process.

Finally, how does the finished product get to the consumer? How does it find its way to the shelf in the store? Again, these are transportation problems in a manufacturing class.

Manufacturing and Construction

What about construction? Why should construction be considered while teaching manufacturing? Isn't it true that manufacturing companies must design buildings? Certainly, if there is an existing building or area within a plant, a production line may be fitted to that. However, given the choice, many companies build new buildings or renovate old buildings.

There is construction information that is significant to many manufacturing processes. What about safety considerations related to the building? Do students study about such things as traffic lanes and safety lanes in machine areas? What about having students study, via problem solving activities, areas such as lighting, heating, ventilation and getting rid of sawdust by designing a dust collection system? Aren't these really technical construction problems? These problems should be studied when teaching manufacturing since they are very important considerations. Industry deals with them and so should students.

A NATURAL INTEGRATION

Technology education teachers should not try to separate the systems. It is nearly impossible because it is extremely frustrating and the result usually is to try to segment or compartmentalize the systems. They really can't be taught that way.

There is a natural working together, a natural integration of systems, that will apply to virtually anything humans do or have done. By focusing on any of the systems and applying some simple brainstorming, one can easily see how the other three systems fit in. Consider the following examples:

1. The computer-aided design of the space shuttle utilized *communication* processes.
2. The special building techniques needed to house that space shuttle required *construction* processes.
3. The problems that were solved to produce unique ceramic tiles to protect the nose cone necessitated certain *manufacturing* processes.
4. The systems worked together naturally, easily, and the result was a *transportation* vehicle.

When a manufacturing course deals with communication ideas, study them as communication ideas. Make it known that these things work together in a natural way. When dealing with moving goods, call it transportation. When designing a manufacturing facility, call it construction. It's all right to do that within the manufacturing course. The same holds true when teaching any of the other systems.

SOME RANDOM THOUGHTS . . .

Throughout the development of technology education, one of the major goals has been to increase levels of technological literacy. The focus, curriculum efforts, promotion, research, teaching, workshops, symposia, conferences, articles, etc., have concentrated on the development of the individual systems of construction, manufacturing, transportation and communication. But, are future leaders needed who are "manufacturing literate" or "communication literate?" Of course "manufacturing literacy" is not a goal, but how does one attain technological literacy by studying manufacturing? Simply, one does not. Technological literacy is attained by studying technology and integrating the systems effectively.

Let's think of technology as "science getting down to business." Discoveries in science often have the potential to better people's lives. Technology is what happens when the basic research of science is put to use by applying that research to solve social or environmental problems. Technology is how goods are manufactured, how shelters are constructed, how goods or people are transported and how people communicate. It is these "things" that make up technology. These are technological systems.

Technology education, then, is the study of the technological systems, i.e., the four systems that humans have used to survive, to adapt, to make their way through history and to become relatively comfortable and safe in this, the 20th century. Therefore, we must study technology to attain technological literacy.

An easy method of studying technology is through the systems. One can study technology in a manufacturing class since the systems are naturally integrated. However, the focus must be on technology, not just the individual system. One must not concentrate on individual systems and illustrate them as stand alone systems. They are not.

SUMMARY

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.

Teachers should take advantage of the natural integration of the systems to help plan more diverse content, to "turn students on" to the study of technology, to get them involved and working on technological problems and to simply have a better, more interesting class. Consistently, teachers should keep in mind the ultimate goal: technological literacy. That goal is more easily reached through integrating the systems of technology into the day-to-day classroom and laboratory activities and information.

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CHAPTER EIGHT

Interpretation of Industry Approach

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As indicated in earlier chapters of this yearbook, technology has had a tremendous influence on all forms of life on "spaceship earth." The present and future needs of world societies demand that a study of technology be included in the education of all youth and adults.

A visit to several industries which manufacture or utilize computers, robots, lasers and other high technology equipment should convince individuals involved with technology education that some restructuring of classroom and laboratory content is absolutely necessary. Perhaps total restructuring is too demanding for most individuals and may result in fear and frustration. A partial restructuring is an excellent alternative. One should select an area or unit of instruction for restructuring and identify his/her "technological comfort level," so as to start the process with a positive mental attitude. This chapter first focuses on defining industry as it relates to technology education. If one is to teach technology education, an important aspect is to teach it by interpreting industry. Although this approach has been used in the past, interpretation of industry remains a viable approach to the teaching of technology education. (Note: Although technology education is the major thrust of this yearbook, this chapter is also concerned with industrial technology education. It is believed that there is a direct relationship between the concepts of technology education and industrial technology.)

The last part of this chapter includes suggested methods, emerging technologies and laboratory activities for the interpretation of industry approach. Substantial research and development efforts of leaders at several universities during the past twenty-five years should be carefully reviewed in the early phases of curriculum change. Current research involving definition of terms, rationale and structure, provides a valuable base for applying this approach to technology education in the classroom and laboratory.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Define industry, technology, industrial technology and technology education.
2. Outline a structure of industry as a part of the study of technology.
3. Explain several features of selected programs focusing on the structure of industry as a content base.
4. Contrast past interpretation of industry programs with current technology education programs and structures.
5. List and describe several activities suggested for junior or senior high school technology education students.

DEFINITION OF RELATED TERMS

Definitions are important if technology education is to be accepted and advanced in the educational institutions of America.

> *Industry*—that part of the societal economic institution that uses resources to produce goods, services, and information to meet the needs and wants of individuals and society (Sterry and Wright, N.D., p. 6).

On the cover of the November 1985 issue of *The Technology Teacher* the following definition of technology appeared:

> *Technology*—1. the application of science and mathematics for specific purposes. 2. the application of knowledge, tools, and skills to solve practical problems and extend human capabilities (1985, cover page).

The words industrial technology combine several concepts. Thus, *industrial technology* can be defined as the application of knowledge, tools and skills to solve practical problems in industry.

The November 1985 issue of *The Technology Teacher* also included a definition of technology education.

> *Technology Education*—a comprehensive, action-based educational program concerned with technical means, their evolu-

tion, utilization and significance; with industry, its organization, personnel, systems, techniques, resources and products, and their social and cultural impact (1985, cover page).

REVIEW OF CURRICULUM DEVELOPMENT BASED UPON AN INTERPRETATION OF INDUSTRY APPROACH

Curriculum Rationale and Structure During the 1960's and 1970's

A quarter of a century ago the curriculum innovators in the field of industrial arts laid the basis for our present day technology education. Our nation suffered a severe shock when the Russians launched Sputnik. It produced an urgent reassessment of our science, engineering and technology programs at all levels of education. The reaction of congress, business, industry and local school districts was to fund educational programs and enter the space race. Industrial arts leaders wrote curriculum proposals and requested funding from the National Defense Education Act and other sources. A total of twenty curriculum approaches are reported in the table of contents of one publication (Cochran, 1970).

Two past curriculum approaches are briefly examined in this chapter to assist the reader in understanding the linkage of two industrially based structures and their impacts on today's technology education. These structures, developed in the 1960's and 1970's, include: (1) the American Industry Project and (2) the Industrial Arts Curriculum Project.

The American Industry Project—the project staff defined industry as the "institution of our society which, intending to make a monetary profit, applies knowledge and utilizes materials and human resources to produce goods or services to meet the needs of men" (Cochran, p. 40).

A detailed analysis of American industry was undertaken and visually explained with a spherical illustration. The sphere of "American Industry" was illustrated as being an interconnection of 13 basic concepts which were then surrounded by a ring representing the environment of American industry. The thirteen basic concepts include: communication, transportation, finance, property, research, procurement, relationships, marketing, management, production, materials, processes and energy. The ring, entitled Environment of American Industry, included:

government, public interest, private property, competition and resources (Householder, 1971).

The program elements in the structure contained three levels. Level I was designed for eighth grade students. The focus at this level was on a broad understanding of some of the major concepts of industry. These concepts included organizing a corporation, mass production, planning for continuous production, preparing prototypes, doing marketing surveys, inspecting products, selling the product and determining a profit or loss.

At Level II, the structure involved an in-depth study of the structure of industry. A series of laboratory experiences consisting of planning, implementing, evaluating and improving manufacturing production formed the instructional content. Each of the above structures contained sub-structures. If the word "planning" was selected from the above, the sub-structures were: routing, scheduling, dispatching and expediting. Students would plan class activities where they would arrange equipment, store and inspect materials, determine time allotments and solve various problems that are industrially related. Level II instruction was developed for ninth grade students.

At Level III, students selected a conceptual area of industry in which they had a strong interest. Students identified a problem, independently researched this problem during the school year and reported the results.

The American Industry staff contributed to a knowledge base for technology education and fostered a desire for other leaders in the field to study and develop a structure of industry.

The Industrial Arts Curriculum Project—acting under funding from the Vocational Education Act of 1963, Lux, Ray, Stern and Towers developed a project proposal which was submitted to the United States Office of Education (Cochran, 1970). The proposal was funded in 1965 and the development of a body of knowledge for industrial technology was started. A publication entitled *A Rationale and Structure for Industrial Arts Subject Matter* was completed. In this document industry was defined as "that subcategory of the economic system which substantially changes the form of materials in response to man's wants or goods" (Towers, 1966).

The project staff identified descriptive, formal, prescriptive and praxiological (technology) knowledge as major organizers. Five institutions in all societies were also identified: familial, political, religious, educational and economic. Industry was placed in the economic section of this structure (See **Figure 8-1**) on page 114. Industry produces economic goods through the material production section of this structure.

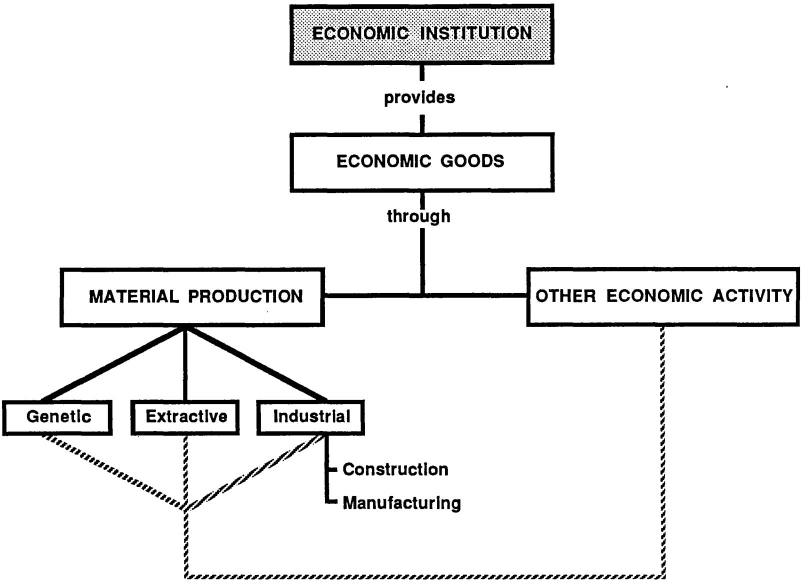

Figure 8-1: The place of industry (construction and manufacturing) in the economic institution.

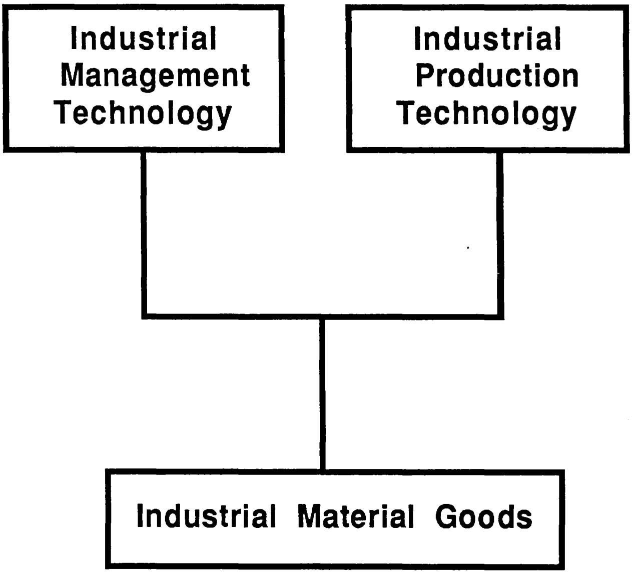

Figure 8-2: The important concepts of industrial technology: management and production result in material goods.

The material production section identifies three areas. These include genetic, extractive, and industrial. Construction and manufacturing are sub-structures of the industrial area and form the content base for a study of industrial technology.

Three important concepts of industrial technology are illustrated in **Figure 8-2** on the preceding page. Note that industrial management technology combined with industrial production technology, results in industrial material goods.

A Three-dimensional illustration places planning, organizing and controlling as sub-structures of industrial management technology (See **Figure 8-3**). Note that preprocessing, processing and postprocessing are sub-structures of industrial production technology. To complete the illustration, the sub-structures of manufacturing (in plant) and construction (on-site) both produce industrial material goods. Each small

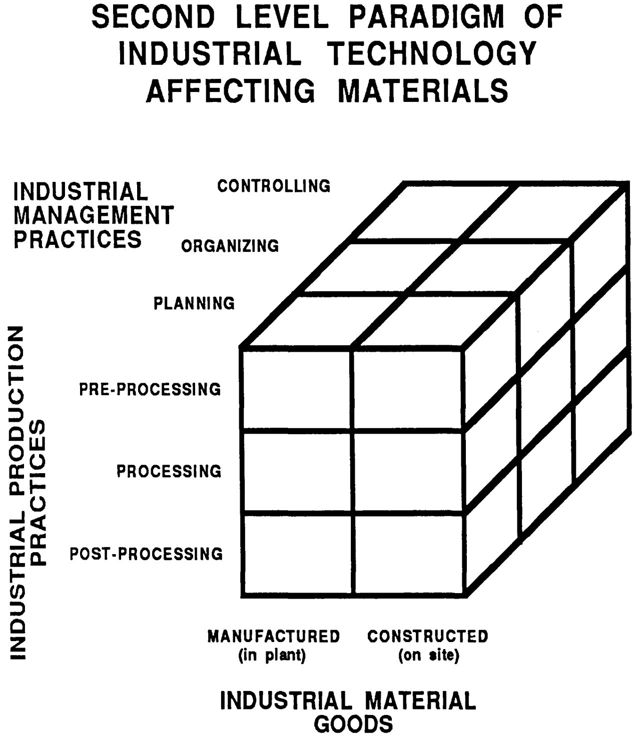

Figure 8-3: Sub-structure of industrial management and industrial production completed in plants and on sites.

block can be removed from the larger block and sub-sub-structures can be identified. This method of structuring and examining a structure is valuable to curriculum developers.

Two courses, each one year in length, were developed from the above structure. The first level course, entitled *The World of Construction*, was designed for seventh grade students. The second level course, for eighth grade students, was titled *The World of Manufacturing.* Both courses contained complete software and hardware materials including a textbook and laboratory manual. The instructional materials were extensively tested and revised over a four year period. All software and hardware (not locally available) were contracted to a commercial publisher and vendor.

The Industrial Arts Curriculum Project, plus A Rationale and Structure of Industrial Arts Subject Matter, the American Industries Project and other projects in the 1960's and 1970's developed a degree of readiness for the profession to move towards technology education.

Review of Current Curriculum Development

The preceding section showed some changes that took place in industrial arts programs during the 1960's and 1970's. These changes came about because of great technological advancements made following the launching of Sputnik by the Russians in 1957. Our country responded immediately by passing legislation and funding educational programs in science, mathematics and foreign languages. Technology-based curricula were soon to follow. Because industrial arts teachers understood the need for relevancy in their programs, and because money was available through federal and foundation grants, a large number of research projects were undertaken. What resulted were many innovative programs designed to respond to the needs of the time. The field moved from a materials-based structure to the more broad-based industrial clusters.

Today we see further development by curriculum writers in our field who have expanded and refined the work of those early innovators. One structure to examine in the interpretation of industry approach is the project entitled *Industry and Technology Education* (Sterry and Wright, N.D.). This project, funded by the Technical Foundation of America, developed content structures for four industrial/technological systems patterned after the *Jackson's Mill Industrial Arts Curriculum Theory* (Hales and Snyder, 1981). Perhaps this was one of the most significant contributions of the past decade. It included the systems of communication, construction, manufacturing and transportation.

In the Industry and Technology Education curriculum all courses have been divided into content structure and are designed to be eighteen weeks in length. Also, three different school-size program models are included and fairly well developed. One is for a small program, one for a medium sized program and one for a large program. Course objectives, content and representative activities are included in materials developed by participants in this project.

Another major curriculum project undertaken during the current decade that attempted to interpret industry and its technologies was *The Illinois Plan for Industrial Education* (1983). This plan was developed to provide educators with an articulated plan for industrial education from Kindergarten through adult levels. Specific curriculum guides were developed for each of four levels: Grades K-5, Industrial Studies; Grades 6-8, Exploring Industry and its Technologies; Grades 9-10, Industrial Technologies; and Grades 11 to Adult, Advanced Technical Studies. A somewhat different structuring of the technological systems was used from that of the two previously mentioned curriculum guides. The Illinois Plan adopted the following four industrial technologies: communication, energy utilization, production and transportation (p. 19).

Other states have followed a similar plan in recent years. For example, Minnesota has adopted a structure very similar to the Illinois Plan in their most recent guide, *The Minnesota Plan for Industrial Technology* (1986). Minnesota was one of the first states to adopt the cluster approach to curriculum development in the early seventies. In the publication entitled *Industrial Education in Minnesota, A Guide for Elementary and Secondary Program Development* (1973), five industrial clusters were recommended: communications, construction, energy, manufacturing and transportation. From this scheme of content organizers, Minnesota's latest plan has evolved to a program called industrial technology with specific curriculum guides developed in four industrial/technological areas similar, but not identical, to the Illinois Plan.

Many curriculum developers have patterned their programs after the interpretation of industry approach. A review of all of these is beyond the scope of this chapter; however, those which have been mentioned should suffice to show that this is still a recognized and viable approach to the study of industry and technology.

WHICH WAY NOW?

The curriculum and methods courses required of majors in undergraduate programs in technology education emphasize the importance of establishing a philosophy of education. Once the undergraduate student has established a philosophy of education he/she must determine a specific philosophy for technology education. The individual's philosophy of technology education must be based upon the tenets of a nationally accepted rationale. In the past, the curriculum area has vacillated between general education and vocational education objectives. A solid rationale and structure and the national movement to technology education should eliminate this confusing problem by placing technology education clearly in the area of general education.

Technology education, taught from an interpretation of industry approach, requires an additional rationale and structure. The trade and job analysis approach is not effective for developing curriculum for technology education.

Perhaps none of the previously mentioned structures exactly fits a teacher's needs. Most teachers are at first somewhat uncomfortable with curriculum change. It is important to have some degree of technological comfort in establishing a course of study. It is also important that technology education teachers be involved as active participants when making a curriculum change.

As instructional strategies are developed utilizing content from industry and technology, strong research bases that justify certain curriculum organizers should be considered. The areas of communication, construction, manufacturing and transportation are popular and well accepted areas. They also have a strong research base and can be justified for inclusion in a technology-based curriculum.

CLASSROOM CONTENT AND METHODS

Several curriculum structures have been mentioned in this chapter, but it should be noted that classroom content and laboratory activities can and should be developed by secondary classroom teachers. Mueller (1985), in his article on "Conducting Field-based Curriculum Development," cited that curriculum leaders have not been very effective at the university level in developing and disseminating curriculum materials. In addition, when these materials have been developed they have had limited acceptance in the public schools.

Classroom content and methods can vary greatly with the technology education approach as indicated in several chapters of this yearbook. The technology teacher has a variety of audio visual materials available to assist him/her in the high technology areas.

Video tapes are available on computer-aided drafting and design. There are video tapes available in the areas of automation and robotics. Sometimes it requires joining an association like the Society of Plastic Engineers to acquire specific audio visual materials. It is well worth the membership fee. There are several excellent 16mm industrial films.

Chrysler Corporation has a film that deals with robotics and computer operated systems in manufacturing. Introductory materials include filmstrips from Damon Corporation with conceptual information on casting, molding, compression, conditioning materials, shearing, chip removal and separating materials by other processes. An excellent film is available from the Society of Plastic Engineers titled "Plastics Imagination of the Future." The classroom teacher can develop many materials for use. Material can be developed easily once the structure is developed.

LABORATORY ACTIVITIES AND METHODS

Hands-on activities in the technology education laboratory should be something that all students experience. Hands-on activities are a necessary part of teaching about high technology. Robotics, lasers, telecommunications and computer production machine interfacing will continue to be important and relevant topics for students involved in industry and technology education. Students need to simulate construction, communication, manufacturing and transportation practices. Group line production activities can present students with experiences in manufacturing management and production technologies. Students can identify a product, design it, make a prototype, prepare jigs and fixtures and finally manufacture, package and market the product.

In the area of communication technology, teachers have developed many laboratory activities. Activities might involve electronic communications in the use of television equipment. Portable equipment may be utilized to record a technical process. An example of a process is the preparation of a photographic stencil (direct or indirect) for screen process printing. Students can work in small groups—three to five students in each group—to plan, organize and control the management activities of a television studio. The student team would select a technical process and plan the presentation, produce the tape and evaluate the television production. In this way they can understand some of the things that are part of television and the area of electronic communications.

A similar type of activity could be developed for radio broadcasting. This is a very important part of the electronic communications area. An activity in visual communications dealing with the production phase may involve such things as planning, organizing and controlling a small business venture. Using a promotional theme one can develop a homecoming button or bumper sticker. Students in small groups of four or five could come up with a unit cost for the preparation of the image and each phase of production using the screen process method. The bid award would go to the best design and final product. Many classroom and laboratory activities can be part of the *interpretation of industry approach.*

SPECIAL TECHNIQUES

Special techniques that can be used in introductory or secondary programs include such things as simulation, gaming, role playing and other activities of this nature. (Games and Simulation are described in Chapter 12.) Simulation gives the appearance and affect of the real thing for, in many cases, the actual activity cannot be directly experienced. Role playing is an excellent method to use in the interpretation of industry approach. An example of role playing is to have students acquire job descriptions and titles from several industries. Students can assume these job titles and role play as they work in various management and production areas. As an example, a student in construction technology could have the role of a job superintendent. This person would have a great deal to do with directing things on the job site.

SUMMARY

Teaching from an interpretation of industry approach can be exciting. Technology teachers should read current journals in communication, construction, manufacturing and transportation, and visit local industries. They should develop or select a rationale and structure that is effective for themselves and their students. A body of knowledge of technology exists and can be utilized to develop an exciting, contemporary technology education program. Technology education is an opportunity for all students, from high ability to those who may have a difficult time grasping some of the concepts. These latter students will acquire an understanding of some of the current practices that are being used in America today.

Technology in communication, construction, manufacturing and transportation will continue to change at a rapid pace. Donald E. Peterson, president of Ford Motor Company, in an article in *Midway* (Kuechle, March 1986), suggested that America will become more competitive. He stated, "We have a game plan to become competitive, and a key element of that plan is the aggressive application of manufacturing technology to achieve worldwide leadership quality and productivity" (p. 23).

If this is the plan of American industry, technology education teachers must plan to make changes. They must plan to make the curriculum reflect society today. The efficient action and application of industrial technology will continue to increase in complexity. Technology education leaders as well as classroom teachers throughout the nation seem to agree that change is needed in this area.

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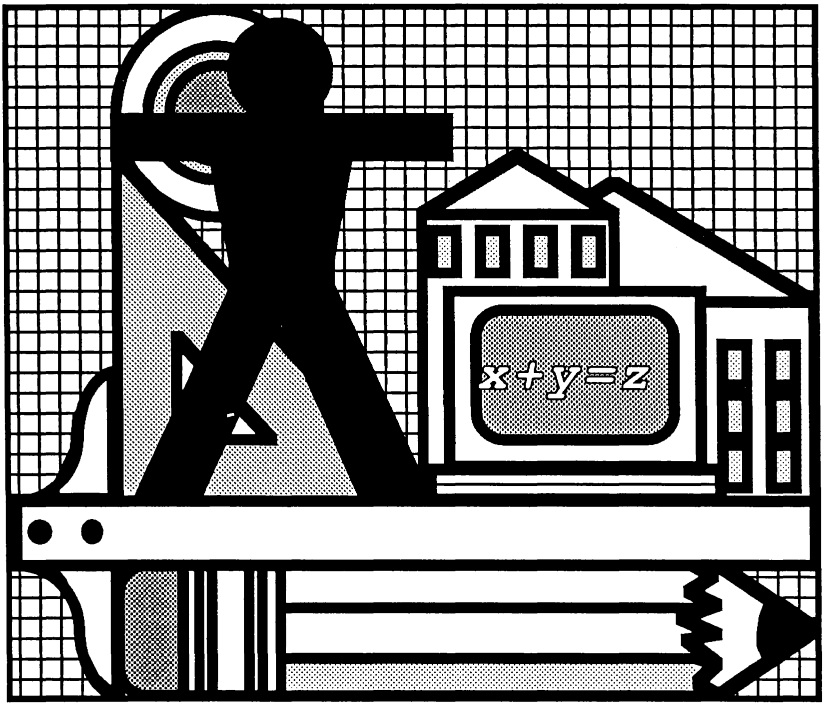
SECTION 3:



DELIVERY SYSTEMS
For Teaching Technology Education

SECTION THREE

Delivery Systems

As defined in Chapter Two, *delivery systems* are the methods that are used to present technological content. There are many forms and types of delivery systems being used today, ranging from textbooks, films and various media to lecture presentations and group activities. The goal of Section Three is to introduce several delivery systems that relate directly to technology education.

Chapter Nine looks closely at delivering content through lectures and demonstrations. Although they are two of the oldest methods of instruction, they still play an important role in the effective teaching of contemporary technology education. Chapter Ten, "Cooperative Group Interaction Techniques," discusses the characteristics of group interaction techniques and the rationale for using them in technology education. It focuses on a cooperative classroom structure where group interaction is emphasized to study new technological content and social impacts. Chapter Eleven, "Discovery, Inquiry and Experimentation," emphasizes the importance of giving students the chance to discover, experiment and develop inquiry skills dealing with technological content in the classroom. Chapter Twelve, "Games and Simulation," looks closely at the need, purpose and characteristics of using games and simulation within the technology classroom or laboratory.

CHAPTER NINE

Formal Presentations and Demonstrations

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Education by definition means change; education in institutions often means sameness, even though educational institutions may mean well in their instructional intentions and directions. Increased responsibility is being placed upon technology teachers to comprehend our modern high technology world and bring those technologies into the classroom. It is not an easy task to stay current in one's academic arena. It is an extremely difficult task for the technology teacher to design teaching curriculum in our world of change and advances.

As if these challenges weren't enough, it is also difficult to deliver the developed curriculum in interesting and challenging ways; ways which the technology student, at whatever level, can find motivating and worthwhile.

This chapter gives the technology education teacher an appropriate awareness of the power of the teaching-learning process, and assists in designing and developing presentations and demonstrations. This assistance can free the technology education teacher from sameness and allow the teaching-learning process to work as it should.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Define and state the purposes of presentations and demonstrations.
2. Explain the technological advances supporting presentations and demonstrations.

3. Describe how presentations and demonstrations are constructed.
4. Utilize elements of adult learning principles in preparing presentations and demonstrations.
5. Construct well-organized presentations and demonstrations.
6. Analyze an instructional message guide.
7. Assess instructional value in media formats and messages.
8. Conduct an analysis of one's own presentation and demonstration skills, compare to recommended approaches and make self-improvements where necessary.

THE PLIGHT OF THE STUDENT

Making effective presentations and demonstrations is as much an art as it is a science. No matter how charismatic a technology teacher may be, learning will be minimized unless instructional content is designed with the needs of the technology education student in mind. The teaching-learning process always starts with the student's instructional needs. The development of presentations and demonstrations starts in a similar way.

Appropriate Analyses

If the desire is to prepare presentations and demonstrations with the students' needs in mind, where and how does one start? Given the significant and varied constraints that technology teachers often have—constraints that prohibit knowing much in advance about students' learning needs—it is not unusual to experience considerable difficulty in planning effective presentations and demonstrations.

For many, if not most technology teachers, what is learned about the technology education student comes the first day of class. It is extremely difficult to plan in advance when so little is known in advance. However, some things can be done to help ensure that the technology teacher becomes an effective presenter and demonstrator.

There are two powerful instructional tactics that can be employed in analyzing not only the students' needs but also in analyzing the entire learning environment to be encountered. These tactics are called *instructional design* and *message design.*

In instructional design the technology teacher attempts to come to grips with the measurable goals and objectives the student should achieve. In message design the teacher considers what materials or messages will best assist in the instructional presentation. Although

The ASSURE Model

A	S	S	U	R	E
Analyze Learner Characteristics	**State Objectives**	**Select, Modify, or Design Materials**	**Utilize Materials**	**Require Learner Response**	**Evaluate**
• Identify Learners • Analyze General Characteristics • Analyze Specific Entry Competencies	• State as Specifically as Possible • State as What the Learner Will Be Able To Do as a Result of Instruction	• Identify Audience - Beginning Point of Instruction • State Objectives - Ending Point of Instruction • Obtaining Materials is the "Bridge" Between the Two	• Plan How Materials Will Be Used • Prepare the Class • Present Content • Follow up with Class "Action"	• Allow the Students to Respond and Give Feedback	• Evaluate the Instructional Impact and Effectiveness • Make Changes as Necessary

Figure 9-1: The ASSURE model uses six steps in planning presentations.

there is no one best way to learn, there are some messages that carry instructional meaning better than others, at least at specific times, to specific students.

Message design is a portion of instructional design. Messages ought not be designed nor implemented without a clear understanding of when, where and how they are to be used. Maximum effectiveness occurs as a result of proper planning and consideration.

A discussion of message design must be preceded by a similar discussion of instructional design. There are many models and examples of instructional design. So many in fact, that an awareness of just a few of them is confusing and discouraging. Each has flaws and merits. The skilled technology teacher eventually develops a model that works best for him/her. This development requires some knowledge of what is, and until that is achieved, a model developed by Heinich, Molenda and Russell (1985), called the ASSURE model, is recommended. See **Figure 9-1.**

ASSURE Model

The ASSURE Model uses six steps in planning for presentations and demonstrations. Each step starts with the appropriate letter in the acronymn ASSURE.

A. Analyze Learner Characteristics—the technology teacher must know something about the students to understand how to determine goals and objectives, and to select or design appropriate instructional messages. There are two important characteristic categories that each student will possess: general and specific.

General characteristics include such things as age, sex, grade level, etc.; factors that are not related to the technological content but are still important to consider. Knowing these characteristics can help the teacher determine the complexity of the lesson or presentation, as well as select appropriate learning examples to share.

Specific characteristics may include the level of content the students might comprehend, learning style preference, content interest and how much is already known about the subject by the student. Students encountering content for the first time may need to have more visually-oriented messages rather than abstract examples.

Although difficult to do at times, analyzing these characteristics is critical in developing effective presentations. The more the teacher can know about the technology education student, the more appropriate the instruction can become.

S: State Objectives—objectives should be stated as clearly as possible, in terms the student can understand and be able to accomplish. Objectives, more specific than goals, are to be attained as a result of the instruction.

Objectives should be designed primarily for the student. An example of an instructional objective might be: "the student will be able to draw the ASSURE model on a blank piece of paper, label each step and describe each of the steps without mistakes." The technology teacher must know the required objectives before media and the delivery systems can be selected or designed to help facilitate any learning that may take place. Objectives must also be stated in such a way that they can be measured. Without explicit objectives students cannot know what is expected of them.

A well-stated objective specifies the *outcome*, or what the student is expected to do upon completion of the instruction. Outcomes must be observable. Measure, select, draw, state or construct are just a few outcome terms that can be measured by the teacher.

A well-stated objective also includes a *condition* under which performance is to be observed. Will tools or equipment be a part of the learning? Will library or other resources be available to the student? Will the student have to rely solely upon classroom notes and memory to perform the instructional behavior? The conditions can be many but they still must be considered.

Finally, a well-stated objective includes the *criteria* or standard of expectation. How much time is allotted to perform the task? How many times must it be performed? How accurate must it be? The statement of evaluation is not difficult but it must be observable and reasonable.

Objectives, as much as possible, should be tailored to the individual. They are not intended to limit, but rather enhance what a student can, and should gain from the instruction.

S: Select, Modify, or Design Materials—the vast majority of instructional materials used in presentations are those produced by the presenter. However, many materials are commercially available and probably better constructed, but they may not be very useful because they do not lead to the outcomes promised. Selection of materials is a skill that needs to be acquired by the technology teacher. Even instructional materials produced at great expense often do not live up to their pretentions.

The technology teacher must preview selected materials to determine learning potential, then make some assessment of how to use them in presentations and demonstrations. The use must be predicated upon the learning or instructional objectives previously stated. A wide variety of materials are available from NASA, Department of Energy, United Technologies and other sources of technological materials.

Sometimes, materials that have been previously produced, locally or commercially, can be modified and used. Here again, having appropriate objectives can guide the modification process. It is easier and less costly to use materials previously produced, even if they have to be modified. Sometimes materials needed do not exist, or if they do, do not seem "right" and must be produced from scratch, so to speak. If this becomes the case the technology teacher needs to remember for what purpose the materials are to be produced.

When producing materials locally, they should be produced so that they can be used again, even in other settings, or by other teachers. This way, the costs and energies involved in the production can be shared in other classes and presentations.

U: Utilize Materials—all previous steps of the ASSURE model lead to the actual utilization process. For maximum potential one should preview the materials to be utilized, practice the presentation, prepare the learning environment, prepare the audience and present the content. Preparation and practice make for better presentations and demonstrations and for better utilization of all the elements in the presentation process.

R: Require Learner (Student) Response—participation in the learning process by the student enhances learning. In education it is often said that the best way to learn anything is to teach it. When the teacher prepares to teach some content he/she must acquire enough knowledge of the content to share it, and the acquiring process continues until one becomes an expert. So it is for the teacher; so it is for the student. The teacher must know enough about the content to properly evaluate any required student response. The technology teacher might not always require a student response, but when expected, the response must be based upon the instruction received.

Discussions, quizzes and other activities where involvement is expected helps learning take place and increases the likelihood that knowledge transfer will occur. Responses may be overt or covert but they should be planned for in advance.

E: Evaluate—have the technology education students learned what was expected of them? Can they perform the tasks they were taught? Can they transfer the knowledge into other areas of technology education? Evaluating student achievement depends upon the expectations of the objectives. Some objectives require simple physical skills such as lifting, throwing or manipulating. Others depend upon high-level intellectual processing such as comparing, contrasting, analyzing, critical thinking or synthesizing. Technology teachers should not teach students to memorize the names of combustion process elements and then test their understanding of the names by requiring a sophisticated drawing and labeling of the process. In this case the evaluation requirement is inconsistent with the instructional objective.

There is an old saying, "tell them what you are going to tell them, tell them, and tell them what you told them." In learning, the surprises should not come from the instructional process but rather from the discovery process. If the student has a clear understanding of the instructional process, the discovery process will take care of itself. Instruction should be straight-forward and objective-based. Learning is branching, discovering and transferable.

When the technology teacher designs instructional messages he/she needs to ensure instructional intent. Messages must do more than merely fill classroom time. One doesn't have to know precisely how to design messages but one must know what messages will or will not work in teaching. Additionally, these messages do not imply any set media format such as videotape or slide/sound set.

Messages may be designed from scratch, in which case they need to be tried out before actually being used. Trying out, or pilot-testing as it is usually called, assists in ensuring validity—that the message conveys what it was intended to do. Messages that are already available, or need to be modified, often have less flexibility in their utilization, but they, too, need some prior examination as to their potential usefulness.

THE POWER OF PREPARATION

Definitions of Presentations and Demonstrations

There are distinctions between presentations and demonstrations. Some of these are quite subtle. Essentially, a presentation is formal, but can have visual and verbal elements. A demonstration can be formal or informal, have visual and verbal elements, but must have logical proof. A presentation simply lays out curriculum or content, which may only be theoretical. A demonstration attempts to prove how technology does or doesn't work; how the technology exists physically. A demonstration may show the operation of some technological concept.

It is important to understand, as technology teachers, the commonalities and differences between presentations and demonstrations. Appropriate understanding on the part of the teacher increases the potential in the delivery to *motivate* students.

Purposes of Presentations and Demonstrations

Technology teachers may give instruction through presentations, demonstrations, professional papers, workshops, seminars, classroom lectures, etc. Each of these delivery systems has its own merits and should be utilized on the basis of identified student learning needs. For example, the seminar is probably the most misunderstood of all instructional delivery systems. In the seminar the student is expected to participate in locating and sharing technological content on a very high level. Quite often the content is centered around social/cultural impacts of technology. The teacher is responsible for ensuring that core content is covered, ensuring that agreed upon content is discussed and facilitating the sharing process. The teacher does not give up the responsibility for bringing important new knowledge to the seminar; knowledge above and beyond those portions agreed upon by all seminar participants. Furthermore, the teacher orchestrates the learning through wise facilitation.

A good rule of thumb for judging when to use which instructional delivery systems relates back to the learning objectives. Of all the content the students receive during an instructional unit, which does the teacher want them to remember on a priority basis? Which is the best way to ensure that the students will correctly receive and comprehend the content, remember it and apply it?

Every teacher, in every teaching situation, ought to use the simplest and least expensive methods and materials that can get the instructional task done. If a handout will work properly, what would be the justification for producing an expensive videotape to accomplish the same effect? There is no valid reason to pay more money or spend more time than is necessary.

The secret in teaching is to view the content and learning experiences through the eyes of the students and develop the delivery systems accordingly. Too often, teachers set and hold time and learning content as the instructional constants, with actual learning being the variable. In public education, especially, there is just so much time allotted for learning to take place. If a student does poorly maybe more learning time is needed. It is better to hold learning as the constant and allow all other factors to become the variables. If one student takes two days longer to understand the objectives, so what? Understanding the objectives and achieving behavioral change is what education is all about, not how much one can learn in a fifty minute period.

The technology students will more readily accept instruction if they understand its relationship to previous learning, especially if delivered in simple, yet positive terms. Simplicity does not mean without merit or validity. In fact, there are companies that commercially produce and sell materials and literature on how to prepare and deliver presentations and demonstrations. The successful ones stress simplicity.

The objective of any presentation or demonstration is to influence the thinking of the students. Sharing facts with students will not guarantee behavior change. When technology students want to do the things they've heard and seen, then instructional goals and objectives are on the way to being met.

Controlling the Learning Environment

A principal responsibility of the teacher is to harness the learning environment and take advantage of all learning possibilities. All teachers, acting as managers of instruction, understand such learning elements as light, seating, air movement, room size, location, etc. Sometimes little can be done to change adverse learning conditions, but just to acknowledge to students that the teacher is aware that conditions are less than the best can be helpful.

Managing instruction requires a good understanding of the teaching-learning process, while considering the needs of both the teacher and the students. One must deal with the environment, materials, equipment, students and one's own self as the teacher. There is much to consider; much to manage.

Learning Readiness

All students ought to be taught on the basis of individualized instruction—not a different direction for each student, but treating each individual as a separate and distinct person. The more the teacher knows about the student (student needs) the greater the chance of learning change or other individual improvement taking place. Student needs are further discussed in Chapter Two of this yearbook.

There is a phenomenon called "learning readiness" which isn't well understood, but is real and must be thought about when planning presentations and demonstrations. Sometimes learning conditions must be adjusted for readiness to happen. Sometimes resistances take place for reasons other than being hungry, tired or disinterested. In the past the burden was primarily upon the student to "get it." Today, teachers understand it is very difficult to learn without well planned learning directions and expectations. Even self-discovery has to have some planning direction.

The truly great technology teacher pays attention to learner readiness and is prepared, through proper planning, to deal with it when it happens. Students are given some flexibility in pursuing their learning. Although they are still expected to "get it," "it" is not forced upon them. Students should be encouraged and challenged to learn when they are ready. Hopefully they will be ready, but teachers must be aware of their state of readiness.

Considering the Components

Technology teachers need to challenge the students, manage the learning, but stay out of the way of learning until reinforcement time. There are learning points, plateaus, happenings, readinesses or whatever else they are called, that happen independent of the teacher, but need to be recognized and reinforced by the teacher. When the "light" goes on in the mind of the student it is critical for the teacher to give guidance for pursuing the excitement of the discovery. The teacher doesn't control the learning but continues to manage the learning process.

The fully prepared technology teacher considers at the onset of the teaching-learning process all the instructional elements whether under control or not. The teacher controls those that can be controlled, and attempts to deal intelligently with those that resist close control.

Most students do not fall into the "ah ha, I finally get it" category. Sometimes it is extremely difficult to detect learning going on. When preparing for learner change one must know what change to expect. Sometimes, conditions will alter the change, even though learning is taking place. What happens if a good student, after having observed the teacher demonstration, fails to recreate the experience, yet seems to have paid attention and should be capable of accomplishing the objectives? Is it possible the student was unable to clearly observe the demonstration? Might his/her view have been obstructed or a distraction occurred at a critical point?

Assume a technology teacher is going to teach a unit on using a microcomputer to design graphics for student projects. The equipment and software are available. Can all the students clearly observe all the steps? Will special projection equipment be required to project the computer screen image to a larger size? Will special lighting conditions need to be made available, such as dimming? There are many other questions that could be asked of the various components involved in the learning experience described.

THE POTENTIAL IN PRESENTING AND DEMONSTRATING

Presentations

All evidence indicates that the lecture is still one of the most used delivery systems. It certainly isn't appropriate for all circumstances but it does have great power, especially when coupled with intelligent and challenging questioning. Too many teachers inadvertently mistake lecturing with one-way communication. In reality, the true lecture can be interactive.

How does the teacher decide when or when not to lecture? Does every teacher need highly advanced training in instructional technology to understand the instructional condition, and know how to apply the various alternatives?

The decision to lecture should be based upon the well-defined goals and objectives the teacher expects the students to acquire. Goals, not media or instructional components, determine the directions of learning.

When the teacher prepares the presentation with *selling* in mind, rather than *telling*, motivation will most always take place. Lectures can help motivate when done properly and with results in mind.

Participation and payoff are the keys to learning. Students must be involved to learn. Some learning payoff must be perceived by the student for paying the price of learning. These payoffs are many and varied. They may be as simple as getting a passing grade on an examination, or as complex as changing one's career. When designing instruction, technology teachers design and implement presentations based upon time, energy, skills and resources. And, the bottom line is that teachers utilize what is available to prepare content.

The ASSURE model discussed previously is only one of several ways of analyzing the instructional need at hand and insuring that any form of presentation, be it lecture or other, succeeds. Some technology teachers will prefer to design their own model. To do this, three things must be kept in mind. First, goals and objectives must be *determined* based upon student needs. Next, the presentation must be *developed* based upon the identified goals and objectives. Finally the well-developed presentation must be *delivered* in an interactive style. Interactive, in this sense can also mean just keeping the audience interested if for some reason immediate student feedback is not possible. **Figure 9-2** shows a complete model of instructional design that can be effectively used.

DEFINE

The identification of instructional goals is the product of defining presentations

(1) The learner's characteristics, learning principles
(2) The learning system; school, society and environment
(3) The learning support of resources, constraints and instructional media centers

DEVELOP

The design of the lesson plan is the product of developing presentations

(1) The subject's content, tasks and objectives
(2) The teaching and learning strategies
(3) The selection of materials, formats, alternatives and evaluation

DELIVER

The evaluation of learning, content and the instructor, is the product of delivering presentations

(1) Prepare the learning environment, internal and external
(2) Practice and vary the style and time, use organizers and be creative
(3) Present so as to "show and tell," involve and interact, get feedback and evaluate

Figure 9-2: The 3-D's Instructional Design Model.

Technological Support

In today's sophisticated electronic world there are numerous exotic resources available to the technology teacher, both in-class and out-of-class. Students typically will not mind homework if they have an opportunity to interact with new technologies in the learning process. The videotape player-recorder is becoming increasingly more accessible to students, thereby affording additional opportunity to study instructional material in one's home. As hardware becomes more available so does the necessary software. Most of the available software for videotape recorders and microcomputers, for instance, is not expensive. Many colleges and universities, as well as many public educational institutions, are developing library collections of these and other new technologies.

If the teacher doesn't know much about electronic delivery systems he/she can still participate in the learning process of high technology. Technology students do not expect the teacher to be an expert in every instance. They do, however, expect teachers to assist them in their learning responsibility. It is all right as a teacher to say "I don't know" today. It is not all right to "not know" tomorrow. The teacher may have to learn alongside the students. Finding resource people to assist in planning presentations and demonstrations is a wise move. In fact, these resource people might very well help in the actual presentation or demonstration.

High technology can be intimidating. It needs a "high touch" applicability. Instead of avoiding new technology on the grounds of its exotic nature, the technology teacher needs to understand the technology on the basis of life-long professional development. Nothing makes a teacher better than continuing personal learning. "High touch" in this case means familiarity; taking advantage of the opportunities to learn about new and interesting ways of teaching and learning.

Although *teleconferencing* (audio only) works well under certain conditions, it generally is not a viable instructional force by itself. However, when coupled with visual information, as in the case of two-way television teaching, the conferencing method has some dynamic potential. Here again, student interaction is the key to success in designing and delivering instruction. Although most teachers may not know much about two-way television teaching today, it is a technology with great promise.

If teachers are to be professionally competent they will have to have their own professional development plan, one in which they network with other teachers who have similar instructional interests. It is imperative that those who practice the art and science of teaching share it through professional organizations, presentations, publications and other forums. Much skill and many excellent instructional activities exist, often known only to those who conceptualized and conceived the learning notions.

One might call the real keys to learning "sharing and comparing" and "sowing and growing." If a delivery system is working and learning is taking place, then it ought to be considered for wider distribution. In this way, potentially all technology students will have the opportunity to learn in the most successful ways. The science of presenting and demonstrating is widely known; the art, however, is personal and comes only to those who care and share.

Utilizing the Principles of Adult Learning

Education has for years been dominated by the pedagogical model of *teaching to the student*. In this model the student is too often passive and merely notes, but hopefully absorbs, what the teacher delivers. Emphasis is placed on student listening with little opportunity for evaluating content and formulating opinions, some of which may run counter to those held by the teacher. Pedagogy is defined as the art and science of teaching; in a sense, it may more correctly be labeled as the art and science of delivering or telling. This model is teacher-based with the bulk of the content coming from the teacher. In contrast, adult learning uses the *andragogical model, which is the art and science of learning*. The principles of adult learning are those under which adults prefer to learn: seeking learning, learning as a means to an end and not the end itself, integration of new concepts into existing knowledge, etc.

All students need to be treated with respect and confidence, regardless of age, content or instructional model(s) used. The andragogical model helps the teacher design and deliver instruction by identifying many specific reasons for involving the student more. In an article on adult learning, Zemke and Zemke (1981) made some powerful statements that can significantly help the technology teacher design instruction. They made a few particularly useful observations:

1. Increasing or maintaining one's sense of self-esteem and pleasure are strong secondary motivators for engaging in learning experiences.
2. There seem to be "teachable moments" in the lives of adults (and maybe in all ages).

3. Information that has little conceptual overlap with what is already known is acquired slowly.
4. The learning environment must be physically and psychologically comfortable.
5. The key to the instructor's roll is control. The teacher must balance the presentation of new material, debate and discussion, sharing of relevant student experiences and the clock.

Some day teachers may discover that students of all ages have more in common in the ways they successfully learn than has been previously considered. It may be wise for the technology teacher to assume this is the case and thus act accordingly.

The Message Is You

In possibly the finest guidelines for preparing presentations available to us (Association for Educational Communication and Technology, 1971), the authors organize their thoughts on how to prepare presentations around preparing creatively, producing the supporting audio-visual materials and setting up the presentation environment. Part of it is summarized in **Figure 9-3**.

Dennis W. Pett, Indiana University (Pett, N.D.), articulated the importance of well designed messages (or materials) for effective presentations and demonstrations. As a result of his work, and that of others, he suggested that to be most effective, the instructional message ought to contain that which is *necessary for the teaching moment.* The technology teacher doesn't need to be an artist to conceptualize instructional messages. However, it may be necessary to obtain additional assistance to produce some of the messages.

Pett stated: "materials (messages) must be carefully planned and production techniques must be sufficient to give good quality." The emphasis is on *careful planning* rather than on *production techniques.* The critical factor in message production is to not produce at a level of quality that would detract from the central message intended. Pett offers three simple design principles that, if followed, will greatly assist the technology teacher in preparing and/or obtaining useful instructional materials. They are:

1. Maintain visual simplicity and verbal clarity.
2. Consider visual verbal relationships.
3. Organize elements for visual verbal flow.

What he means by each of these is further explained in **Figure 9-4** on page 140.

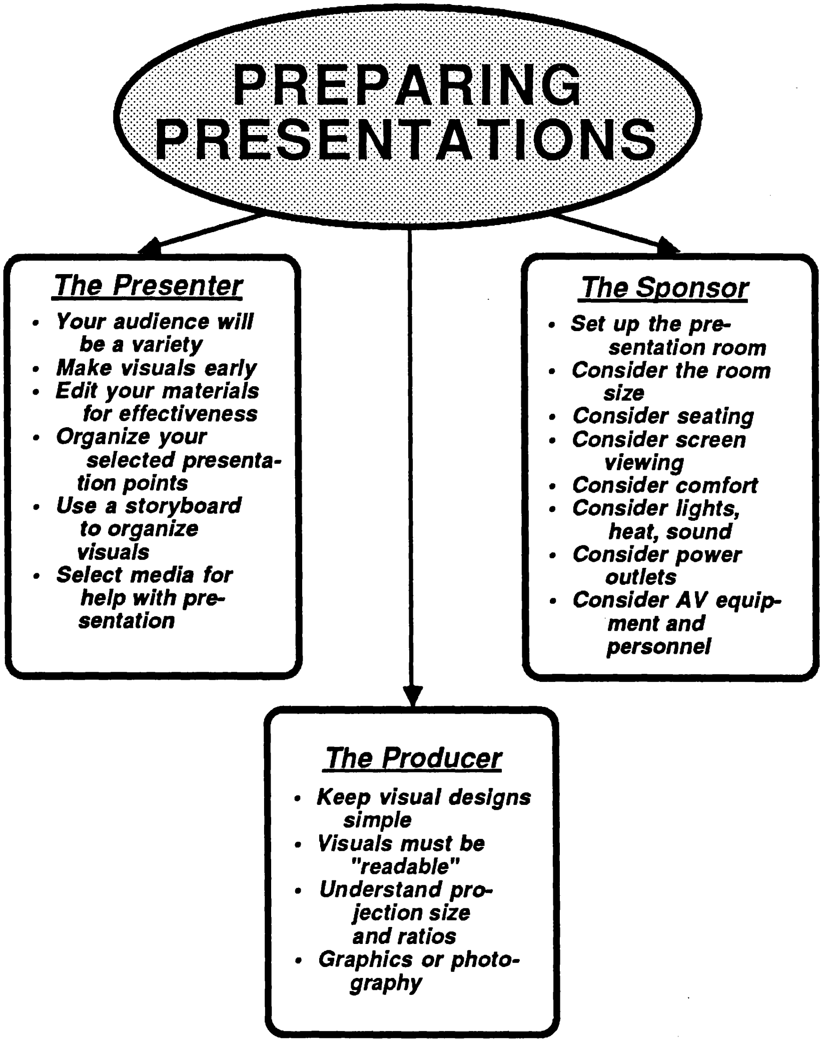
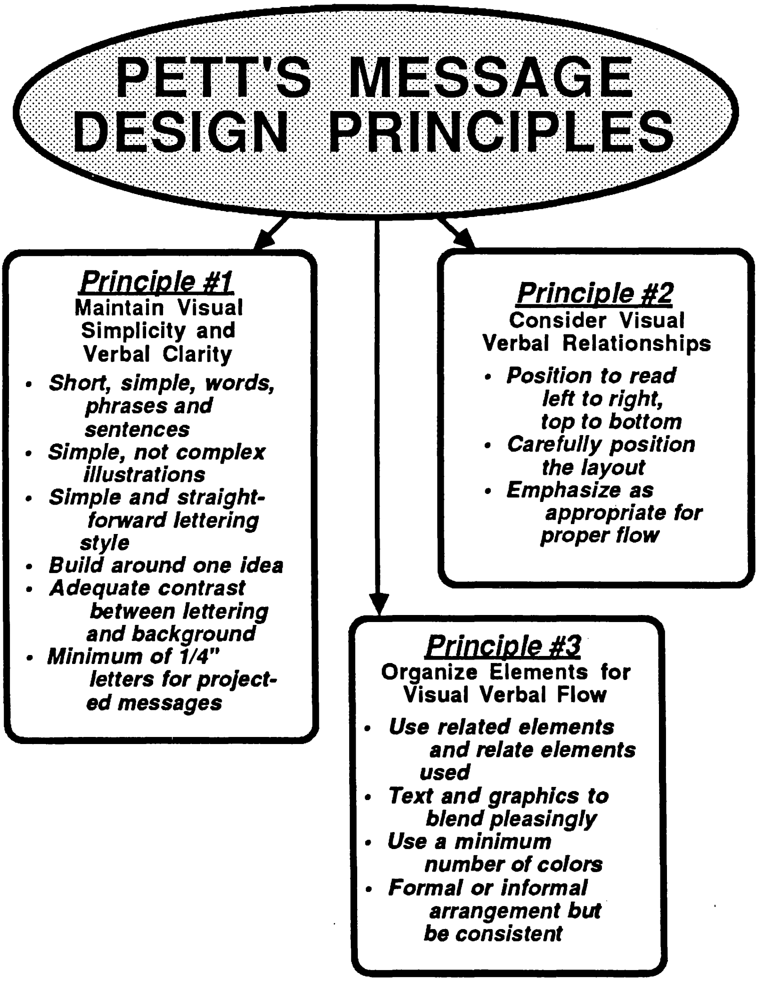


Figure 9-3: Guidelines for preparing presentations.



PETT'S MESSAGE DESIGN PRINCIPLES

Principle #1
Maintain Visual Simplicity and Verbal Clarity
- *Short, simple, words, phrases and sentences*
- *Simple, not complex illustrations*
- *Simple and straightforward lettering style*
- *Build around one idea*
- *Adequate contrast between lettering and background*
- *Minimum of 1/4" letters for projected messages*

Principle #2
Consider Visual Verbal Relationships
- *Position to read left to right, top to bottom*
- *Carefully position the layout*
- *Emphasize as appropriate for proper flow*

Principle #3
Organize Elements for Visual Verbal Flow
- *Use related elements and relate elements used*
- *Text and graphics to blend pleasingly*
- *Use a minimum number of colors*
- *Formal or informal arrangement but be consistent*

Figure 9-4: Pett's Message Design Principles.

The technology teacher will realize that all presentation and demonstration materials or messages should be built around one idea, with a few quite easily understood visuals and a minimum of words arranged for greatest verbal impact. Messages must be designed to involve the technology student.

Demonstrations

A demonstration is a unique kind of presentation; one that is performed. Demonstrations are effective for teaching psychomotor as well as cognitive objectives. They can also be used to illustrate other skills such as interviewing, disciplining, counseling and selling.

A successful demonstration closely matches the verbal and visual elements of the presentation; if at all possible with simultaneous matching. A good demonstration correctly "shows how to do something," or "how a particular technological concept operates" rather than merely "telling about it."

In preparing for a demonstration the technology teacher follows the same procedures as for preparing any kind of presentation, except in choosing the accompanying visual support. One may choose from real things, pictures, models, films or filmstrips, slides, other graphic materials, etc., to support the teaching. Creativity and curricular imagination are important characteristics for the technology teacher to possess in order to develop quality demonstrations. This creativity will assist greatly in selecting the right "match" of the verbal/visual teaching requirements.

Timing is also an important consideration in planning for and delivering a demonstration. Not only must the verbal and visual elements match but they must flow in the proper sequence and reach the logical conclusion. The technology education student should be able to replicate the demonstration. If not, the demonstration is of questionable value.

Another factor in preparing and presenting a successful demonstration deals with space. The technology teacher must have room in which to "work" the demonstration. The students must be able to view the demonstration sufficiently to replicate it.

Presenting a demonstration requires some "showmanship" techniques. It must be properly sequenced, building to its logical conclusion, with sufficient interest factors to hold the student's attention and curiosity. A good showman understands that the audience must be able to observe and hear to be able to understand.

Since the technology teacher quite often teaches the "real" of the technology world, demonstrations are a natural part of the teaching-learning process and given on a regular basis. Like any other part of the curricular process, demonstrations have their place, and are highly effective when they are well done.

A final key in preparing and presenting a good demonstration is to allow the earliest possible student try-out of the demonstrated skill. In fact, it isn't necessary to demonstrate a complete operation before observing student performance. A demonstration can proceed in steps of sequence, with student performance following each step demonstrated before the next step is taught (or group of steps).

It is critical that the technology education student be given every opportunity to have learning reinforced until mastery is accomplished. The students themselves will learn to identify the difference between their try-outs and the eventual desired performance.

SUMMARY

One should learn, as a result of reading this chapter, that learning is personal and requires structure and control. The technology teacher can make a tremendous difference in the lives of technology education students by carefully assessing the learning requirements of each student individually, and each class of students collectively. When this is done the presentations and demonstrations will become exciting and powerful, will be appreciated by the students and will ultimately make a learning difference in the lives of each student involved.

Dugan Laird (Laird, 1978) summarized much of what has been written in this chapter, although he wrote specifically for trainers in corporations. It would be useful to review his book and discover that the elements of the teaching-learning process are essentially the same whether for trainers, technology teachers or instructors in other settings. Furthermore, he includes visualizations of various presentation environments and stresses the importance of making the learning location comfortable.

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CHAPTER TEN

Cooperative Group Interaction Techniques

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Talking is as natural to young people as walking. When a class period ends, the rate of speaking increases sharply. Technology teachers who monitor the hallways between class periods often refer to the enthusiastic exchange of ideas by students as pandemonium, a madhouse or some more descriptive words. Technology teachers have a set of instructional tools and when used skillfully can convert excessive idle chatter into exciting and informative exchanges of ideas. These focused exchanges of ideas are referred to as interaction techniques. When correctly selected and implemented in a cooperative setting, the use of interaction techniques can lead to increased student understanding, social growth and positive attitude development.

Cooperative group interaction techniques are classroom activities that are designed to capitalize on the human desire to talk and to share ideas. Personal interaction is an activity in which two or more people are actively involved in exchanging ideas. When interaction techniques are used in the classroom, students become valued resources and a vital element in the teaching/learning (T/L) environment. Students develop a sense of belonging and personal value because their ideas are received and respected.

In a T/L environment the technology teacher plays a key role. It is the technology teacher who organizes appropriately sized groups with the necessary skills, and who helps the groups choose goals that are interesting, relevant and attainable. For group techniques to be effective, teachers must know their students, know about group dynamics and be able to use that knowledge in ways that result in productive learning.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Describe and give examples of group interaction techniques.
2. Describe the characteristics of a cooperative group interaction learning environment.
3. State a rationale for using cooperative group interaction techniques.
4. List and describe the four major tasks a technology teacher has to complete in order to implement a cooperative group interaction teaching/learning strategy.

INTRODUCTION TO COOPERATIVE GROUP INTERACTION

Technology teachers can structure learning experiences so that students are in a win/lose struggle for success. Another option is to allow students to learn individually on their own. Finally, technology teachers can create conditions whereby students work cooperatively in pairs or in small groups.

Each instructional structure can contribute to learning. Technology teachers should possess the skill to know when and how to structure T/L activities competitively, individually and cooperatively.

Competitive structures encourage students to work against each other in order to achieve. There is a negative interdependence between students. They perceive that they can obtain their goals if and only if other students in the class fail to obtain theirs. Therefore, students seek outcomes that are beneficial to themselves but detrimental to those with whom they are competing. However, a competitive structure teaches students how to survive in a competitive world.

Individualistic structures limit growth. Students work alone to achieve individual goals. They work independently and at their own rates and perceive their learning goals as unrelated to what other students do. However, students do have an opportunity to follow a learning trail independent of others.

In cooperative learning situations students reach their learning goals if and only if other students in the learning group reach their goals. They seek outcomes that are beneficial to all those with whom they are linked.

This chapter focuses on the third—cooperative classroom structure in which group interaction is emphasized. Three basic questions will be addressed:

1. WHAT are cooperative group interaction techniques?
2. WHY use cooperative group interaction techniques?
3. HOW does one implement cooperative group interaction techniques?

WHAT ARE COOPERATIVE GROUP INTERACTION TECHNIQUES?

Their Nature

There is a multitude of teaching/learning (T/L) techniques from which to choose. To make it easier to understand interaction techniques, all T/L techniques have been put into three categories—presentation, action and interaction techniques. The prime distinction between the categories is the role students play in the implementation of the T/L technique.

In *presentations*, students are relatively inactive and passive. They listen, take notes and perhaps ask a few clarification questions while the technology teacher, guest lecturer or some form of audio/visual equipment presents information to the class.

Action techniques involve the student directly with ideas, materials, objects and equipment. The students are no longer passive observers. When students are involved in action techniques they construct, experiment, observe and otherwise physically move their bodies to manipulate objects in an effort to develop skills, learn procedures, observe physical phenomena, understand an abstract principle or use a principle, skill or process in a new situation. The technology teacher is less active and serves more as a facilitator than presenter.

Interaction techniques capitalize on the human desire to talk and to share one's thoughts. Personal interaction is an activity in which two or more people contribute and exchange their ideas. A major advantage of interaction techniques is that students and their ideas become resources and thus major elements of the T/L environment. The technology teacher is more of a cheerleader then and less of a participant. Students become the active contributors rather than the passive receivers.

Kinds of Interaction Techniques

Descriptions and suggestions for implementing ten interaction techniques follow. The techniques are described in greater detail in *Lesson Planning for Meaningful Variety in Teaching* (Henak, 1984).

Questioning—in life people use questions to gain information. In teaching, questions are used to facilitate learning. Technology teachers can use questions for diagnostic reasons—to find out, at the beginning of instruction, how much students know and how they feel about the subject matter. A second use of questions it to assess achievement at the end of instruction. Such questions are intended to evaluate each student's understanding of facts and principles presented during class and the ability to apply them. Questions can be used as an instructional tool at the beginning of a lesson to promote interest. What if . . . ?, Why . . . ?, and How would you . . . ? questions can be effective in gaining the attention of students. Finally, good questions encourage students to think more deeply on technological subjects and challenge their reasoning power.

There are four kinds of questions teachers can use in the classroom. *Closed questions* are probably the least effective in developing participation in classroom interaction. They usually are identification, selection or yes/no in nature. *Probing questions* are asked to challenge students to clarify, justify, refocus, expand and deduce ideas. *Divergent (open-ended) questions* require that students think ahead in time, fantasize or guess what might happen. *Evaluative questions* ask students to make judgments about conditions, decisions, theories and solutions.

Discussions—when groups of people share their ideas on a topic in conversations, they are engaging in a discussion. This technique is most useful when the objectives for the instruction are related to clarifying ideas and values, and to solving problems when several likely alternatives are being considered. Discussions have the potential of expanding each student's understanding or principles and concepts. Technology teachers may also use discussions to diagnose the level of understanding and the feelings students have about the subject.

When members of a group hold differing views on a subject, discussions are useful in helping them clarify and develop values that lead to developing maturity in the group members.

Finally, discussions give students an opportunity to develop their abilities to exchange ideas in a group. They are able to practice expressing ideas, share in verbal interaction and develop the ability to make a logical presentation of ideas about a topic.

Buzz sessions—more participation is possible when a discussion group has from five to twelve members. In buzz sessions, a class is divided into smaller groups to interact on a topic or to achieve a goal. There are at least two kinds of buzz sessions. The first is probably the most familiar. It is referred to as the reaction session. Members of a large group listen to a presentation of a provocative or controversial issue in technology. The large group is then divided into small sub-groups, where members discuss the ideas presented earlier: problems, difficult questions or controversial elements. Time is allowed for the sub-group leaders to present to the main group a summary of the ideas that were discussed in the sub-group.

The planning buzz session provides students with the opportunity to participate in the planning of future topics and classroom activities. The objective of this variation is to involve students in such activities as formulating questions to be asked in a student interview or of a guest speaker.

Brainstorming—the brainstorming technique is used when the quantity of potential solutions to a problem is more important than quality of the ideas. The technique is a problem-solving activity designed to stimulate and generate ideas and to facilitate their expression.

Solutions are solicited without regard for their practicality. The members of the group are instructed to suggest as many ideas as possible without the threat of censure or judgment. They should be uninhibited and "free wheeling."

Technology teachers who use brainstorming sessions need to orient students by stating the anticipated goal and instructing them to make only positive statements, avoid evaluating any of the ideas, use their imagination and add to others' ideas. All ideas should be recorded, then later synthesized and discussed in order to select the best ideas. The best ideas are then put into practice.

Seminar—the seminar is a structured group that meets as the group deems necessary, to facilitate meeting the goals of the group or of individuals. The use of this technique can improve communication within the group, facilitate coordination of group activities, increase vicarious learning by group members, raise the cohesiveness and morale of the group and facilitate finding solutions to problems being solved by group members.

Planning a seminar is the responsibility of the chairperson, who can be either a student or the technology teacher. The chairperson's tasks include preparing the agenda, presiding over meetings, introducing guests and maintaining the time schedule. It is best to follow an agenda which may include the items listed on next page:

1. Introductions
   - —Guests
   - —Presenters
2. Progress reports
3. Presentations
4. Discussion and/or questions
5. Individual problems
6. Closing comments
   - —Visitors
   - —Instructor's summation
   - —Chairperson's formal conclusion

Interviewing—journalism and broadcasting use interviewing extensively. Probably the most useful characteristics of the interview technique are: (1) its inherent mobility, (2) its utilization of community talent, and (3) its availability of potential resources outside the school.

Interviewing can be used both as a process and as content. When used as content, students enjoy many opportunities to develop their communication and social skills. As a process, it is an effective method for gaining information. In order to maximize this characteristic, students must select productive talent to interview, prepare appropriate questions, organize the questions so the interview moves forward and record responses.

The student interviewer(s) have a choice. The interviewer can go to the specialist for the interview or have the person being interviewed come to the school. The approach selected is determined by local conditions. If only one person needs the information from the expert, the interviewer will probably go to the specialist. However, if the entire group needs the information, it may be easier for all involved to have the specialist visit the school.

Role-playing—role-playing is a method of human interaction that involves realistic, spontaneous behavior in an imaginary situation. Role-playing can provide students with the opportunity to:

1. Experiment with new ways of behavior.
2. Tailor situations and roles to fit their needs.
3. Practice real-life situations.
4. Risk making mistakes without the consequences of these errors.
5. Observe more objectively because less ego is involved with the roles being played.
6. Bring real-life behavior into the classroom.
7. Develop human interaction skills.

In planning role-playing lessons, the technology teacher must decide how much structure to give the roles. If the objective is to clarify values or to develop an understanding of another's cultural values, the roles are often left undefined. When the objective is to focus on how individuals function in certain situations, the role-playing lesson is more highly structured and the number of optional responses is limited. In any case, it must be assumed that participants are not to be ridiculed and one is not playing him/herself.

Variations in the role-playing technique include switching roles, imitating another person's role, guessing why a statement was made and wheel-leaders who ask each person to respond to an issue. The students who are not participating in the role-playing activity can become more involved if they are asked to listen and watch for biases, preconceived ideas and body language used by the participants.

Gaming—in free play, children often find ways to compete fairly and simulate parts of their world. Educators can use this characteristic by using gaming techniques in the classroom.

Two kinds of games are useful in the classroom. Simulation games center on life situations. Players advance in the game by responding with answers or decisions to questions, situations or conditions. Through their experiences, students develop a deeper understanding of the dimensions, procedures or critical conditions encompassed by the game. Although some technology teachers have done it, this kind of game is difficult to design.

The question/answer game is easier to design and is adaptable to any subject matter; therefore, it is more commonly used in the classroom. The rules are usually patterned after a popular game such as football, Trivial Pursuit, or Bingo. The technology teacher writes the questions from the subject matter in the course. The rules should be written in a way that makes winning and losing depend more on how well the students or student teams know the subject matter than on chance. It is best to identify cooperative teams rather than individuals, because in cooperative teams the less talented students are encouraged by other students to study for the game and develop a sense of belonging. In the event of winning they share the reward. If the team loses, the less talented are less visible than if they were competing on an individual basis. (More detailed information on this topic may be found in Chapter Twelve, *Games and Simulation,* in this yearbook.)

Committees—there are times when the task to be completed is too large for an individual to complete and too cumbersome for the entire class. Social skills such as cooperation, leadership, followership and persuasion are potential outcomes from student directed committees. These skills are badly needed by citizens of the future if they are to become effective, contributing participants in self-governing groups so common at local, state and national levels.

To ensure success with this technique, it is essential that committee members be willing to spend the time needed to achieve the goals, are representative of the relevant interests in the group and can work well together. Secondly, committee assignments and work guidelines must be clearly identified.

Debates—students can learn analytical, communicative and persuasive skills when the participants carry on a debate. Debates are "pro and con" discussions of a question or issue in technology. Debates usually involve two teams of three or four students. This technique is an excellent way for team members to learn about controversial topics. If in-depth learning by the total group is the goal, the debate method should not be chosen.

The description that follows is a modification of typical debate rules so that the competitive element of debate is minimized and so that student interest, voluntary participation and identification are encouraged. The teacher can implement the technique by first introducing the purpose, rules and procedures to be used. The topic should be current, relevant, within the student's range of ability and researchable with available resources. When identifying the teams, an attempt should be made to balance backgrounds, intelligence, interest and verbal abilities of the members. The technology teacher then sets the date for the debate and provides equal assistance to both sides in their research.

The following procedure is recommended for carrying out the debate. One may wish to shorten the procedure by omitting certain items, but retain the balance between the sides. The recommended procedure follows:

1. State the problem to both teams.
2. Give five minute formal presentations (affirmative, then negative).
3. Give five minute rebuttals (affirmative, then negative).
4. Request questions and/or contributions from floor.
   —Affirmative, then negative.
   —Repeat as needed.
5. Make three minute summary speeches (affirmative, then negative).
6. Open the floor to questions.
   —Include speakers and audience.
   —Balance participation between sides.
7. Summarize the new information.

Approaches to Using Cooperative Group Interaction Techniques

The word "approach," in this context, means the degree to which the technology teacher or students direct or control the exchange of ideas. Interaction techniques such as questioning, discussions, brainstorming, buzz sessions and role-playing are more often than not organized and directed by the technology teacher. However, student interviewers, seminar leaders, participants and committees often are student-directed learning experiences. The maturity of the students, the purpose of the activity and, most of all, the degree to which the technology teacher believes that the students can direct their own activities determines which approach is used.

Teacher Directed—the goals and objectives in teacher directed techniques are established and the activities are directed by the technology teacher. The technology teacher often determines the focus for the student interaction experiences and the time spent on them.

Student Directed—in student directed interaction experiences the goals and objectives are established through agreement between students and teacher. When common agreement is not reached within a reasonable time, the decision is made by the technology teacher. The purpose of the collaboration is to establish clear, mutual expectations. The technology teacher monitors the group work and provides assistance when needed.

WHY USE COOPERATIVE GROUP INTERACTION TECHNIQUES?

American citizens have always placed great value on education. Their hope for the future is that somehow the schools and colleges will prepare the next generation to meet successfully the challenges of the 21st century in a world with increasing population, finite resources, deteriorating environment, rising expectations and a growing technology that (to many people) seems out of control. The challenge of educating our future citizens has never been greater than it is today. Dr. Paul DeVore in a keynote address at Symposium '80 (1980, p. 21) stated:

> Where people once considered the present to be stable, they find their lives being altered on almost a daily basis by forces beyond their control. With the advent of more powerful and disruptive forms of technology, used by more and more people worldwide, quantitative changes of great magnitude have occurred.

We are experiencing exponential growth in technology, new forms of communication, energy use, specialized knowledge and perhaps most significantly, higher and higher levels of destructive power. We now have the potential, through the use of machines, chemicals or nuclear power, to alter or destroy the human race and/or ecological systems of the Earth. Never has there been a greater need for a responsible, informed and socially sensitive world citizenry. The methods of instruction used by technology teachers must be the ones found to be the most effective in helping students:

1. Achieve higher levels of understandings of technological and ecological systems and their interrelationships.
2. Develop higher level learning and critical thinking skills.
3. Contribute more to the well-being of others.
4. Develop higher levels of social responsibility.
5. Become effective participants in collective human action.

Achieve Higher Levels of Understanding

Increased achievement and long-term retention of information often results from the verbal rehearsal of information through frequently introducing, repeating, explaining and integrating information. Well managed technological conflicts involving ideas, opinions, conclusions, theories and information from group members can result in greater motivation to learn, higher achievement, longer retention and greater depth of understanding.

Develop Higher Level Learning and Critical Thinking Skills

It was stated earlier that the use of cooperative interaction learning groups tends to promote higher levels of achievement than competitive, individualistic or "traditional" learning situations. A series of research studies aimed at identifying the factors contributing to the success of cooperative group learning was conducted by Johnson and Johnson (1983). They found that cooperative efforts usually resulted in greater achievement on the higher level learning tasks. Tasks included were: concept attainment, verbal problem solving, categorization, spatial problem solving, retention and memory, motor learning, higher reasoning strategies, greater critical thinking competencies and guessing-judging-predicting. Also, more positive attitudes towards both the subject area and the learning experience were noted. Finally, discussions lead to higher cognitive levels of learning as compared to the "traditional" methods.

Contribute More to the Well-being of Others

Over the last several years Johnson, Johnson, and Maruyama (1983) have studied the effect that cooperative, competitive and individualistic learning situations have on the social development of students. They found that cooperative learning experiences seem to increase the sense of belonging and acceptance, appreciation and liking of others, acceptance of self and collaborators, self esteem and the desire to enjoy future interactions with group members.

Develop Higher Levels of Social Responsibility

Cooperative learning experiences were considerably more successful in developing students' appreciations for each other than competitive, individualistic and "traditional" ones (Johnson and Johnson, 1983, p. 136, and Johnson, Johnson, and Maruyama, 1983, p. 36). Differences in ability level, sex, handicapping conditions, ethnic group, social class differences or task orientation seemed to have no noticeable effects on the positive outcomes from cooperative learning experiences.

Johnson, et al. (1984, p. 20) defined social perspective-taking as:

> . . . the ability to understand how a situation appears to another person and how that person is reacting cognitively and emotionally to the situation.

The researchers go on to clarify the meaning of perspective-taking by describing its opposite (p. 21) as:

> . . . egocentrism, the embeddedness in one's own viewpoint to the extent that one is unaware of other points of view and of the limitations of one's perspectives.

Cooperative learning situations resulted in higher levels of perspective taking in both the cognitive and affective domains than did competitive and individualistic learning situations (Johnson and Johnson, 1983, p. 136-137).

Become Effective Participants in Collective Human Action

The technology educator's classroom must be future oriented if satisfactory solutions to problems related to technology are to be found. The success of collaborative efforts in Japanese industry and of employee involvement groups (quality circles) in this country is well documented. Cooperative interaction groups provide an opportunity for students to learn collaborative skills and to experience the benefits of working cooperatively. Considerable research documents that members in cooperative interaction groups develop collaborative skills at a higher level than do those in competitive and individualistic learning settings (Johnson and Johnson, 1983, p. 139-140).

HOW DOES ONE IMPLEMENT COOPERATIVE GROUP INTERACTION TECHNIQUES?

After one understands what cooperative group interaction techniques entail and why they are used, the next issue is to discuss how technology teachers can effectively use this delivery system. What follows is a procedure that provides guidance, yet is flexible enough that it can be adapted to specific learning situations.

Planning Cooperative Group Interaction Experiences

Planning begins long before students arrive in the classroom. Planning requires the technology teacher to make many decisions related to what is to be learned, where it is to be learned and how the people, space and resources will be organized to maximize the positive returns from the learning experience.

Identifying Objectives—objectives of most classroom instruction in the public schools can be placed in at least three categories. The first and most familiar category contains the subject matter objectives. They describe the intended cognitive, psychomotor and affective behavior changes to occur in the learner. The second category of objectives is management objectives. They are seldom stated; however, a significant amount of class time is used to communicate to students deadlines, clean-up procedures, locations of materials, classroom rules, standards of behavior and other classroom management information. The last category of objectives describes the cooperative skills that students are to learn. Technology teachers often discuss the problems related to teaching cooperative skills, but little is being done to alleviate them.

In *Circles of Learning* (Johnson, et al 1984), the authors have summarized the findings from years of research into four levels of cooperative skills.

1. Forming—the bottom-line skills "directed toward organizing the group and establishing minimum norms for appropriate behavior." (p. 45).
2. Functioning—the skills used in "managing the group's efforts to complete their tasks and maintain effective working relationships among members." (p. 46).

3. Formulating—this set of skills is needed "to build deeper level understanding of the material being studied, to stimulate the use of higher quality reasoning strategies, and to maximize mastery and retention of the assigned material." (p. 45).
4. Fermenting—the skills in the fourth level are "needed to stimulate reconceptualization of the material being studied, cognitive conflict, the search for more information, and the communication of the rationale behind one's conclusions." (p. 47).

A major question at this point is, "Who determines the objectives?" Does the technology teacher take full responsibility, do the students decide or is the selection of the objectives a shared responsibility? There is not space here for a full presentation of this topic but textbooks have been written on the values of teacher directed, student directed and participatory approaches to classroom management. However, there is one guideline which seems to surface in much of the contemporary classroom and business management literature. That guideline states that people should be allowed to participate in the decisions that affect their lives. The degree to which the technology teacher will allow students to be involved in selecting the objectives is dependent upon the flexibility and acceptable options in the subject matter and classroom management, the students' cooperative skills, and the faith the technology teacher has in the ability of students to make educational decisions.

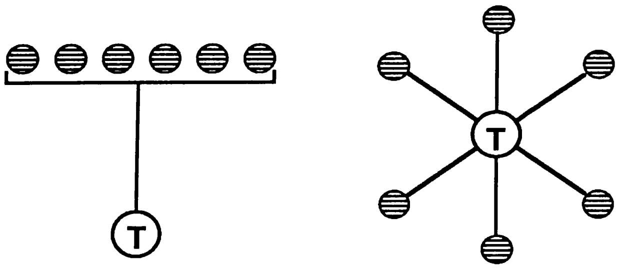
Organizing the Setting—after the objectives are determined, the technology teacher needs to establish the group by determining the optimal group size and assigning students to the groups. A group size of from two to six is typical for cooperative learning groups. Johnson, et al. (1984, p. 26-7) list the following variables to be considered when establishing cooperative groups:

1. As the group increases in size, the range and number of potential ideas and solutions increases.
2. The difficulty in reaching a consensus, getting equal participation from all members and keeping members on task increases as the group size increases.
3. As the length of work time decreases the size of the group should decrease.
4. The objectives and available resources may determine the optimal group size.
5. When the teacher or students are inexperienced in cooperative group work, the group size should be kept at two or three.

When students are assigned to groups, teachers need to decide if the membership in the group is to be homogeneous or heterogeneous in terms of ability, task orientation, educational and ethnic backgrounds, and whether the group membership should be changed periodically. When assigning the group membership, technology teachers are usually better able to assign groups with a heterogeneous membership. Student-selected groups have a tendency to have a homogeneous membership that is selected on student interests that are unrelated to the learning task. The more experience students have working in cooperative groups, the better they are at building teams to complete learning tasks.

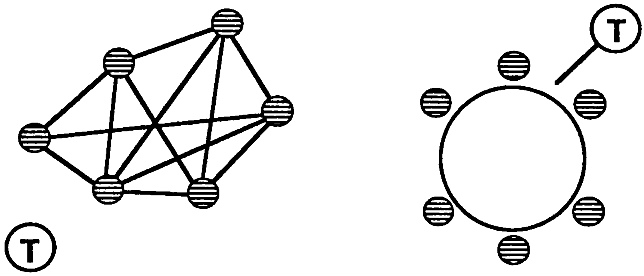
The arrangement of classroom furniture sends a symbolic message about what is expected from students. **Figure 10-1** illustrates four room arrangements that send different messages to the students. The first, Tutorial Setting (A), suggests that the instructor presents information directly to students in a lecture format. The Discussion Group Settings (B and C) indicate that students are more involved in classroom activities. When the technology teacher is central (B), the students ask questions of the teacher. In the third illustration (C), the students assume more of the responsibility for asking and seeking answers or responses to the points brought out in the discussion. Variations of the Discussion Group Setting (C) are recommended for cooperative interaction learning groups. Round tables are recommended for the larger groups so that all members are able to have eye contact. The Work Group Arrangement (D) is shown with the teacher on the fringe, acting more as a facilitator.

The more mature the group is in cooperative learning, the less the technology teacher will have to plan for positive interdependence. These efforts are designed to communicate to individual group members that they are a team, that each has a responsibility for making the group function efficiently and that they must cooperate with each other if they are to complete the task, earn the grade or receive the reward. Three of the ways to build this cooperative feeling are: to provide only one book or reference that all members have to use, give each of the members different resources that must be synthesized and assign roles to ensure interdependence. These roles may include the "group leader" who sees that everyone is involved, coordinates activities, assesses the work completed and reports results. The "recorder" writes down ideas and records decisions. The "stop action" person controls disruptions and helps the leader maintain focus by calling "stop action" when a group member disrupts progress. The roles can be periodically changed if it will benefit the productivity of the group.



A. Tutorial Group

B. Discussion Group (teacher central)



C. Discussion Group (teacher on fringe)

D. Work Group (teacher on fringe)

Figure 10-1: Room arrangements send messages about the kind of interaction that is expected between students and the instructor.

Leading Cooperative Group Interaction Experiences

The technology teacher's responsibility in leading cooperative group interaction learning experiences is to initiate the activities, structure interdependence and specify the criteria.

Initiating Activities—when the technology teacher initiates the group cooperative interaction experience, it is the first contact the learners have with the learning situation. At this time, the technology teacher explains the learning task by clearly describing the assignment and by stating or helping students state their own objectives for the learning task.

Structuring Interdependence—the purpose of this step is to communicate that the goal is a "group" goal and that all group members must work together, as a team, to achieve the goal. Members of the group must,

> . . . understand that they are responsible for learning the assigned material, making sure that all other group members learn the assigned material, and making sure that all other group members successfully complete the assignments, in that order. (Johnson, et. al., 1984, p. 32)

The above authors suggest that interdependence can be achieved through asking "the group to produce a single product, report, or paper," and by giving group rewards and bonuses when the group's performance is above a criterion level.

In learning cooperatively, each member is expected to learn the subject matter; and the success of the group depends on it. Therefore, individual accountability is required. Periodically checking on each student's performance and reporting his/her progress is needed so that all group members know who is succeeding and who needs encouragement and help.

Specifying Criteria—the criteria used to assess successful achievement in cooperative learning is criterion referenced rather than norm referenced. This means that an acceptable level of performance is established and clearly stated at the beginning of the learning experience. This criterion may be stated in terms of a level of achievement, problem to be solved or simply that the learning task has been completed.

Criteria describing the group behavior are also needed. These criteria are based on the level of skill the group has developed in using cooperative learning skills. Objectives that were identified in the planning stage serve as the basis for these criteria.

Monitoring Cooperative Group Interaction Experiences

When students begin their group learning, the technology teacher's role changes from presenter and discussion leader to observer and facilitator. The observer monitors the group's collaborative behaviors. When difficulties or problems arise, the technology teacher becomes a facilitator and provides assistance when and where it is needed.

Observing Behavior—technology teachers who choose to use cooperative learning experiences must decide what is to be observed, who does the observing and how the observations are to be made.

What does one observe? At first, technology teachers may watch only for who is talking and to whom they are talking. As observation skills improve, attention is directed to what is being said. In *Learning Together and Alone* (Johnson and Johnson, 1975) the authors listed the interaction behaviors that contribute to productive and cooperative group interaction. The list includes contributing ideas, asking questions, expressing feelings, actively listening, expressing warmth and liking for group and group members, encouraging members to participate, summarizing, checking for understanding, relieving tension and giving direction to the group.

The main thrust is to look for the positive behaviors and build on them. In *Circles of Learning* (Johnson, et al. 1984, p. 35) the following recommendation is found:

> We look for positive behaviors, which are to be praised when they are appropriately present and which are a cause for discussion when they are missing. Especially useful are skillful interchanges that can be shared with students later in the form of objective praise and perhaps with parents . . .

Who does the watching? Generally, the technology teacher is the observer, especially when the teacher and/or students are new to cooperative learning situations. Later, students can help in observing student behaviors. Self-assessment procedures are used while the group is functioning. These may be in the form of brief questionnaires or discussions.

How are the observations made? Whenever possible, formal observation techniques should be used. They may consist of instruments and procedures such as those described by Chasnoff (1979), Johnson and Johnson (1975) and Johnson and Johnson (1982). Short discussions on what happened during class are useful in obtaining input from students about how the group is functioning. Modifications of the feedback form shown in **Figure 10-2** (p. 160) may be useful in helping students focus their observations on specific areas of concern.

Providing Assistance—monitoring the behavior of cooperative group members is like periodically checking academic progress by testing or project reviews in which examples of work are assessed at different stages in the development of a larger project. These observations are used to help the technology teacher and group members diagnose problems of accountability or lack of skill. The information is useful in identifying where intervention is needed to ensure success in the learning experience.

Intervention may come in the form of providing practice in academic or collaborative skills and serving as a consultant. Intervention should be kept to a minimum and students encouraged to solve their own problems. Numerous intervention techniques and how to use them are included in Johnson and Johnson (1982), Johnson (1978, 1981) and Johnson, et al. (1984).

FIVE-MINUTE CHECK

WORK SHEET

How well do you think the Group is doing?

1	2	3	4	5
Poor		Average		Excellent

1. **Poor**-Many people are not involved. The Group discussion is really off target.
2. **Could be a lot better**-Some people not involved. The Group discussion wanders most of the time.
3. **Average**-Most people are involved. The Group discussion works well some times.
4. **Good**-All people are involved. The Group discussion is on target most of the time.
5. **Excellent**-Everyone seems involved. The Group discussion is on target all of the time.

Comments or Suggestions:

____

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Figure 10-2: Worksheets help to identify information that is useful in conducting short Group reviews that last about five minutes.

The information gained from the observations is also invaluable in planning for future cooperative learning experiences. It verifies the cooperative skills students have mastered and the skills in which additional help and experience are needed.

Evaluating Cooperative Group Interaction Experiences

The evaluation of cooperative learning experiences has two dimensions. They are: (1) evaluating the quantity and quality of learning and (2) evaluating the level of functioning within the group.

Evaluate Learning—evaluation of learning is relatively easy if during the planning stage the objectives and criteria were clearly specified and communicated. Evaluation is a matter of observing the work and comparing its quantity and quality to stated standards and granting rewards in the manner agreed upon.

Evaluate Functioning of Group—assessing the quality of the group's functioning is as important as reaching the learning goal. Without evaluating the cooperative skill development objectives, little or no growth will occur in the group's cooperative skills; nor will the anticipated gains in achievement occur.

Modifications in the questionnaires shown in **Figure 10-3** and "Group Review Chart" similar to the one shown in **Figure 10-4** on the following page (Baker, 1980, pp. 182-189) can provide specific input

Skill 1: Seeking opportunities and problems

Effective opportunity seeking means really looking at your work place to find the right problem. Sometimes the most urgent and pressing problem is not the most important one. Important problems are often hidden and /or not discussed. People's hopes and dreams can often point the way to great opportunities.

Rating	Explanation
1	No one asked the question,"Is this the right problem?"
2	Different problems and opportunities were mentioned but dropped.
3	An effort was made to explore different problems and opportunities but no attempt was made to set priorities in choosing the problem to work on.
4	Different problems and opportunities were listed and prioritized but the process was dominated by a few vocal members. Hopes and frustrations were not expressed.
5	The Group systematically gathered information about problems and opportunities. We set priorities based on both urgency and importance. The Group shared its hopes and dreams as well as its true feelings and frustrations.

Figure 10-3: In-depth information can be collected by using a questionnaire on each level of cooperative skill.

for discussions in cooperative learning groups whose task was to identify and solve a problem. The format is easily altered so that the chart represents the cooperative skills needed to reach other kinds of learning goals. Use graphic methods to summarize the information collected from the group. The illustration in **Figure 10-5** shows how the instrument in **Figure 10-4** can be visualized. Each of the skill ratings (1-8) has been placed on **Figure 10-5** on a scale from poor (1) to excellent (5). Visualizing these ratings gives the instructor a better evaluation for improving discussions.

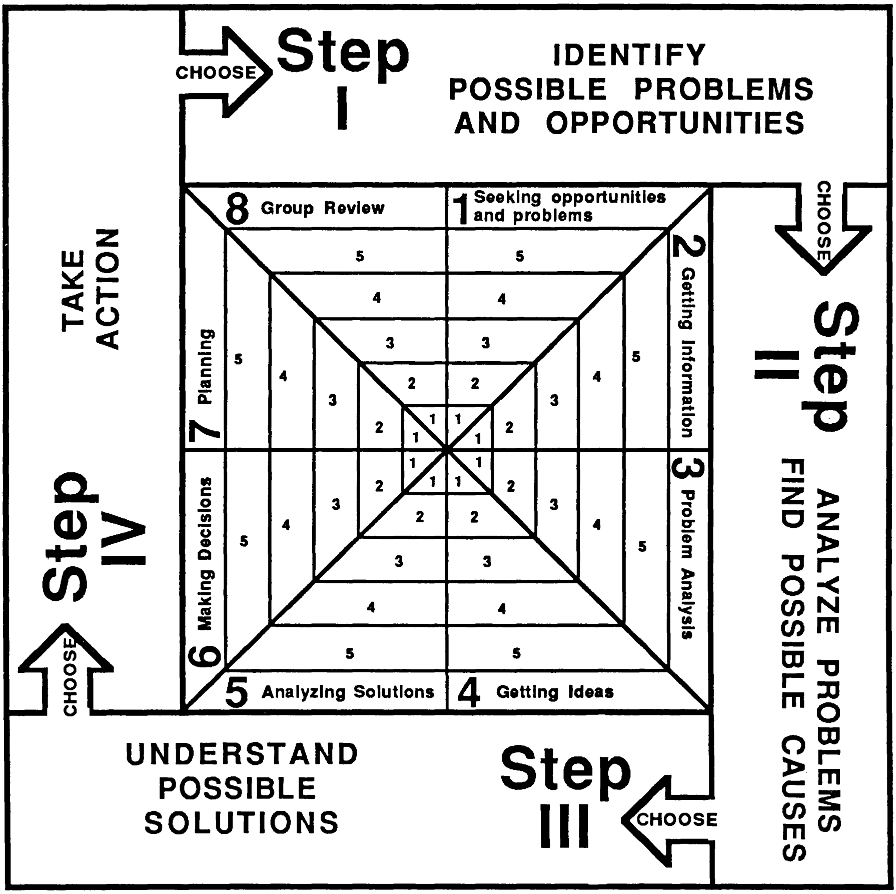


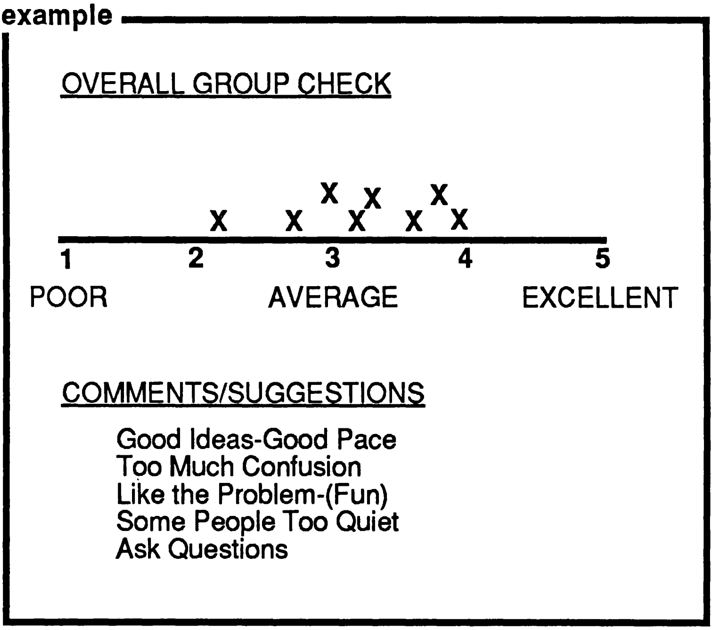
Figure 10-4: The group Review Chart is an effective method for analyzing information collected with questionnaires.

Group Work

-Members, in turn, share their ratings and comments. The writer puts these on the flip chart.

-The Group discusses "high" ratings this meeting and any "low" ratings at the next meeting.

example



OVERALL GROUP CHECK

COMMENTS/SUGGESTIONS

Good Ideas-Good Pace
Too Much Confusion
Like the Problem-(Fun)
Some People Too Quiet
Ask Questions

Figure 10-5: Visualizing information helps in directing discussions.

A discussion should center around the cooperative skills that were present or obviously missing, if growth in using participatory activities is to occur. During these discussions care should be taken to:

1. Describe what happened rather than evaluate who did it.
2. Refer to specific situations rather than generalities.
3. State both the good and bad rather than only one side.
4. Be open and honest rather than avoid problems.

SUMMARY

In this chapter individualized, competitive and cooperative learning environments were described. Teaching/learning techniques were categorized into presentation, action and interaction techniques. Ten interaction techniques and the cooperative group interaction learning environment were described.

The cooperative group interaction learning experience was found to be the most productive learning environment. The cooperative environment resulted in higher achievement, in learning to use higher levels of learning skills, in developing higher level collaborative skills and in greater personal growth in acceptance of self and others. The research indicated that cooperative learning environments were consistently superior to individual and competitive learning environments over a wide range of learner characteristics and subject matter.

Suggestions for implementation of the cooperative group interaction approach to instruction included recommendations for planning, leading, monitoring and evaluating achievement of subject matter, higher level thinking skills and collaborative skills.

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CHAPTER ELEVEN

Discovery, Inquiry and Experimentation

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Discovery, inquiry and experimentation are useful instructional techniques for the technology teacher to consider. These investigative delivery systems compose a model of teaching that educational theorists have identified as **inquiry training.** In this chapter "inquiry" will be used to represent all forms of discovery and experimentation used in the classroom. The instructional design of inquiry training provides the technology teacher with a delivery system to enhance student growth and development. There is an unlimited number of problem-solving and decision-making learning activities that can be developed to utilize this delivery system.

The nature of this instructional design is ideal for challenging students to learn about past, present and future aspects of technology. It is also an appropriate way to present technical and social/cultural content. Inquiry training is an excellent delivery system for facilitating technology-based projects. Many industrial arts teachers throughout this century have included some inquiry in the traditional "project method." By using inquiry training as the basis upon which the project idea is discovered, designed and constructed, the project becomes technological in nature. Throughout history, many technological breakthroughs have been made by individuals investigating problems or areas of interest. It is essential that the technology teacher understand how to facilitate learning for technology education. Through using an inquiry training delivery system, the classroom teacher can provide students with excellent instruction to increase their technological literacy.

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Analyze the theoretical and practical nature of learning by discovery, inquiry and experimentation.

2. Describe the instructional variables that affect the use of inquiry training in the classroom.
3. Apply this delivery system in the classroom to understand technical and social/cultural content.

INTRODUCTION TO INQUIRY

Technology teachers will find inquiry training a useful model for hands-on or hands-off classroom lessons that involve problem solving or critical thinking. This delivery system is appropriate for individualized, small group or large group instruction. The instructional design of inquiry training makes it a practical method of teaching in the general classroom or in special needs programs. Because of the flexibility of this delivery system, technology teachers will find that inquiry training can make their teaching become more effective.

INQUIRY TRAINING MODEL

Inquiry training is a mode of teaching that focuses on the process of investigating and explaining unusual phenomena. Inquiry involves questioning. In the classroom, the teacher presents students with a problem or puzzling situation. Students ask questions and try to develop hypotheses that will fully explain the problem or situation. Inquiry training is an organized teaching model in which students experiment, ask questions and develop conclusions about technological content.

Suchman developed inquiry training in the early 1960's (Suchman, 1964, p. 23). Prior to his research there was not an inquiry procedure for the classroom. Students experimented freely and randomly proposed questions. Suchman's research of inquiry training investigated how people think when they inquire. He developed the model primarily from studying the work of Bruner, Piaget and Dewey. Bruner's report that people tend to organize their search for new ideas according to patterns they have found successful in the past influenced Suchman's belief that there was need for the inquiry training model. Piaget's work concerning operational thinking of children in school led Suchman to speculate that there are certain styles of thinking that are more productive than others. Dewey's suggestion that the scientific method be used in the instructional process provided Suchman with a logical framework to develop this model of teaching. From his research, Suchman developed the inquiry training model which is essentially a cognitive strategy that enables individuals to solve problems through organized investigation and discovery.

Purpose and Goals of Inquiry Training

The purpose of inquiry training is to teach students the skills of investigation so they may apply the strategy in their learning process. The students apply the skill they have acquired to gather and organize data, isolate variables from experiments, create hypotheses and draw conclusions concerning the problem situation. By utilizing the inquiry training model, several chief learning outcomes are attempted to be achieved. These are as follows:

1. Students acquire process skills of observing, collecting and organizing data; identifying and controlling variables; formulating and testing hypotheses and explanations.
2. Students develop independent learning techniques that involve asking questions, testing ideas and making decisions.
3. Students enhance their ability to express themselves verbally by asking questions. Likewise, their listening and comprehension ability improves from receiving answers and synthesizing the replies.
4. Students acquire persistence through data gathering and experimenting to solve the problem situation.
5. Students develop logical thinking skills through following an organized method of inquiry.
6. Students learn a strategy by which new knowledge can be obtained.

Suchman (1964) believed an overall outcome of inquiry training was to make the learner more productive. He believed:

> a) Learning through inquiry transcends learning which is directed wholly by the teacher or the textbook; the autonomous inquirer assimilates his experiences more independently. He is freer to pursue knowledge and understanding in accordance with his cognitive needs and his individual level and rate of assimilation. b) Inquiry is highly motivated because children enjoy autonomous activity particularly when it produces conceptual growth. c) Concepts that result from inquiry are likely to have greater significance to the child because they have come from his own acts of searching and data processing. They are not just abstractions that have been structured by the words of other people. They are formed by the learner himself from the data he has collected and processed himself; and for that reason should be more meaningful to him, and hence more stable and functional (p. 2).

Inquiry Training Process

The inquiry training model involves taking in and processing data. Suchman (1964) identified that in the process of inquiry there are four main types of action. These are searching for information, data processing, discovery and verification. It is essential that these actions form a cycle of operation by which the inquiry process takes place. Joyce and Weil (1980) have explained the inquiry process through five phases. They concisely stated that inquiry training consisted of: (1) encountering students with a problem, (2) data gathering—verification, (3) data gathering—experimentation, (4) formulating an explanation and (5) analyzing the inquiry process (p. 73). **Figure 11-1** illustrates the inquiry training process.

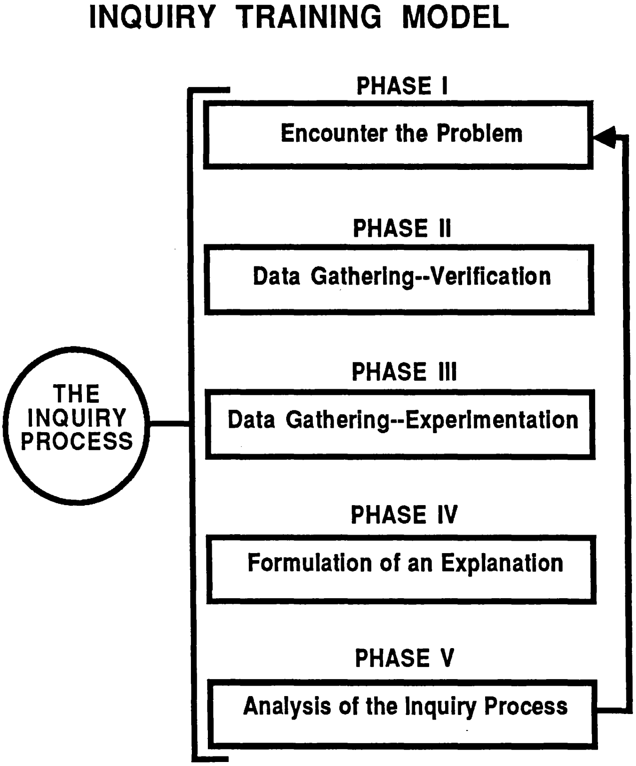

Figure 11-1: The inquiry model involves students accomplishing five phases. Upon completing Phase V, students should be prepared to encounter a new problem. The more students are involved with the inquiry process, the higher the level of inquiry skill they will possess.

Phase I—during phase one of inquiry, the teacher confronts the students with a problem or puzzling situation. The teacher also explains the rules of the inquiry process. Students are instructed to only ask questions that can be answered yes or no. If a demonstration, trick, or event is to be presented, it is given at this time.

Phase II—the second phase of the inquiry process involves data gathering and verification. Commonly, students gather information and attempt to verify the nature of objects and conditions through questioning and observing. In this phase, students attempt to verify the occurrence of the problem situation.

Phase III—in phase three of the inquiry process, students are involved in data gathering and experimentation. The students may introduce new elements into the situation to isolate variables. The experimentation allows students to explore and conduct direct tests of the variables that have been identified. At this time in the inquiry process, students should attempt to develop hypotheses regarding the problem situation.

Phase IV—the fourth phase of the inquiry process involves the students formulating an explanation of the problem situation. The teacher will call on the students to present their conclusions. Some students may have difficulty synthesizing the data they have gathered and formulating a clear explanation. Because different explanations may be correct, it is often suggested that several students express their explanations. Then the entire class can put the explanations together to solve the problem situation.

Phase V—an analysis of the inquiry process finalizes the inquiry model. During this phase, students study how to improve the inquiry process. Students may attempt to identify the types of questions that were most beneficial in solving the problem. They may analyze the data gathered through the experiments that were conducted. If formulating explanations was a significant problem, some students may wish to discuss the format of developing clear explanations.

Implementation of Inquiry Training

The inquiry training model has been used in various subject areas in the school curriculum over the past twenty years. During the mid-1960's and early 1970's, inquiry training was viewed by science and social studies teachers as a curriculum innovation that would lead students to think critically and stimulate their interest through more active participation in the classroom (Weaver, 1985, p. 161). The Maryland Plan was one industrial arts curriculum model developed in the 1960's and 1970's that structured the total curriculum around a problem-solving organization (Maley, 1973, p. 2). Despite the development of the Maryland Plan, inquiry training was used only to a limited extent in past industrial arts classrooms. It must be understood that prior to the transition from industrial arts to technology education the nature of learning in many of these traditional programs emphasized technical skill development. The learning that took place was often competency-based technical training.

The development of technology education shifted the emphasis of the classroom subject matter from technical training to enhancing students' *technological literacy.* This implies that technology education is most concerned with providing instructional units for students to become capable of answering the following questions:

1. How do people develop new technology?
2. How do various forms of technology work?
3. How can people use technology most appropriately in today's world?
4. How does the rapid growth of technology affect people?
5. What technology assessment is needed to control new technology for a safe future?

These chief concerns of the technology teacher create a natural setting for students to inquire about the problems of technology. It also seems practical to consider the inquiry training model as a means of instruction in technology education because data gathering, experimenting, hypothesizing and drawing conclusions about investigations have always been a process used to research and develop new technology. The development of the wheel, lever, pulley, inclined plane, wedge and screw are examples of technology problems solved by early civilizations through the use of an inquiry technique. Likewise, more notable inventions made during the industrial revolution and since that era are results of inquiry efforts. Bessemer's development of the steel converter, Whitney's development of interchangeable parts, Edison's invention of the incandescent bulb, the Wright Brothers' engineering of the airplane controls and Ford's innovation with automobile assembly methods are just a few examples of foundational technological developments that resulted from people inquiring to solve problems that existed for society.

Bensen (1980) identified that the efforts made to develop new technology to provide for people's needs and wants could be studied in the technology classroom through a unique instructional model he entitled "Societal Problem Approach." This model emphasized analyzing areas of human endeavor along a time line to investigate problems. Bensen stated: "The research and experimentation as well as the design and development mode of teaching through inquiry and knowledge

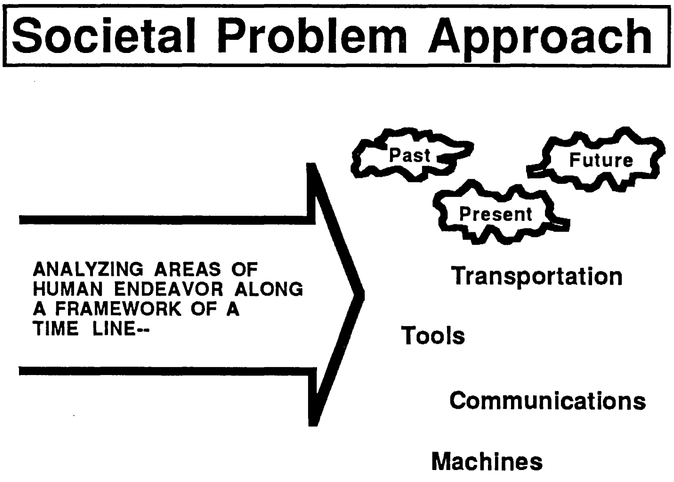

Figure 11-2: The Societal Problem Approach analyzes past, present, and future technology problems. (Source: Bensen, 1980, p. 13)

applications is an extremely motivating approach to education" (p. 13). **Figure 11-2** illustrates the "Societal Problem Approach."

The implementation of inquiry training as a delivery system for technology education can be viewed as a way to enhance problem solving and critical thinking of technology students. Because this delivery system proposes many possibilities and limitations, it is important that teachers fully understand Bensen's model prior to applying it in their classrooms.

APPLICATION OF INQUIRY TRAINING IN THE TECHNOLOGY CLASSROOM

To apply inquiry training in the technology classroom, teachers must understand the inquiry process. It is very important that teachers realize the instructional variables that may influence the various phases of the inquiry model. Next, instructional preparation is critical for teachers to design inquiry lessons that are applicable to the area of study. Because technology education curricula are structured around four main content areas (communication, construction, manufacturing and transportation), teachers' lesson plans will need to focus on problems relating to these areas of study. The third main concern teachers must address is the learner's role in the inquiry process.

Instructional Variables

Whether or not a technology teacher is successful in using the inquiry model may depend upon whether he/she considers the instructional variables that may affect the lesson plan. There are five key instructional variables that should be considered in planning an inquiry lesson. These are:

1. Student maturity level.
2. Organization of the class.
3. Time schedule allowed for the lesson.
4. Facility capabilities.
5. Staff cooperation and coordination.

The following explanation of each variable will provide the technology teacher with a better understanding of what should be considered in planning an inquiry lesson.

Student maturity level—the age and intelligence of the students are two important factors that the teacher must initially analyze to determine the pattern of inquiry. The patterns depend on whether the teacher or student controls the steps of inquiry. Birnie and Ryan (1984) developed a continuum of inquiry learning patterns, **Figure 11-3**. As illustrated by this continuum, patterns A and B have more teacher involvement and patterns C, D, and E involve a greater degree of student participation. It can be concluded that the less mature the students,

A Continuum of Inquiry Learning Patterns

Steps	*A*	*B*	*C*	*D*	*E*
1. Stating the problem	T	T	T	T	S
2. Formulating the hypotheses	T	T	T	S	S
3. Developing a working plan	T	T	S	S	S
4. Performing the activity	S	S	S	S	S
5. Gathering the data	S	S	S	S	S
6. Formulating the conclusions	T	S	S	S	S

Figure 11-3: The pattern by which the inquiry lesson is conducted depends upon if the teacher or student controls the inquiry process. The teacher (T) and students (S) may control various phases of the inquiry process. (Source: Birnie and Ryan, 1984, p. 332)

the more involved the teacher; and the more mature the students, the less involved the teacher. Commonly, patterns A and B would be used with younger students and C, D, and E with older students. In special cases, such as an elementary gifted program, the teacher may find pattern C, D, or E to be more appropriate. In a secondary school learning disabled program, A or B may better facilitate learning.

Organization of class. The way in which the teacher organizes the students for the inquiry lesson may be influenced by the class size. A teacher with a small class may engage students in the inquiry process individually. A teacher instructing a large class may divide the students into groups. Another factor that may influence the organization of the class is the complexity of the problem situation the teacher has selected. For the purpose of classroom management, simple inquiry problems may better be investigated by students individually, and complicated inquiry problems analyzed by small groups.

Time schedule allowed for the lesson. Naturally, the more complicated the inquiry problem, the more time that should be allowed for the lesson. Inquiry training lessons can be designed to occur in one class period or may be developed to last a number of days or weeks. The technology teacher must consider the detail that will be involved in the data gathering phase of inquiry. If students are involved in hands-on experiments to collect data, the time frame of the lesson will need to be longer. The amount of time to be allowed for the inquiry lesson is an important consideration in assuring that the students attain the intended learning outcomes.

Facility capabilities—since most technology education departments are equipped with general tools and machines to process wood, metal and plastic materials, the technology teacher may wish to involve hands-on learning as part of the inquiry process. The extent to which experiments may be carried out for data gathering may be limited to the sophistication of the facility. If the teacher wishes to engage the students in an inquiry problem relating to high technology, the facility may not be adequate for true experiments to be conducted. The lack of proper equipment and inadequate safety measures may limit the experiments that can be permitted in the facility. An example of such an inquiry problem could be a teacher presenting students with the problem: What makes a laser work? The technology facility probably does not have a laser or a safe area in which to conduct laser testing. The teacher could present the problem and suggest that students develop a model laser from cardboard and plastic to help them organize their data and comprehend the operation of a laser.

Staff cooperation and coordination—the possibilities and limitations of inquiry training to some extent depend upon the technology teacher and other teachers in the school. Inquiry training can provide an ideal setting for interdisciplinary study. Problem situations can be presented that interface mathematics, science, social studies, technology education and other school curricula. (See Chapter Four, Interdisciplinary Approach.) An inquiry problem that may be considered involves the previous example pertaining to: What makes a laser work? The data gathering/verification phase may involve students asking mathematics, science and technology questions. The data gathering/experimentation phase may involve students applying mathematical formulas to calculate the speed of light and heat displacement. Science principles regarding light deflection and reflection may be used in experiments. Students may build a model of a laser to investigate the various parts that cause it to function. Cooperation among teachers is essential to conduct interdisciplinary inquiry lessons.

The variables that have been analyzed were presented in an order that may be beneficial to the teacher. This order was developed to help teachers consider the variables which they may encounter in a logical procedure when planning an inquiry lesson. Examining the instructional content that must be prepared is the next aspect to consider when applying inquiry training in the technology classroom.

Instructional Preparation and Design

Technology teachers need to accomplish several tasks in preparing and designing inquiry training lessons. Initially the teacher must identify the course objectives to be accomplished by using the inquiry model. Next, the teacher will need to develop a problem situation that emphasizes the course objectives to be accomplished. The teacher must then decide upon the nature of the inquiry lesson. Several questions that may be asked in making this decision are:

1. Should the inquiry lesson be hands-on or hands-off?
2. Should students inquire individually or in groups?
3. Should the inquiry pattern be teacher controlled or student controlled?

The teacher will also need to design a class atmosphere for the inquiry lesson. If the nature of the inquiry lesson involves hands-on experimentation, the class atmosphere may be of an open laboratory setting. If the teacher designs the inquiry lesson for individual inquiry in a classroom, the atmosphere would be very structured. Because the teacher is the facilitator of learning, he/she is also responsible for preparing or making available any needed materials for the data gathering phases in inquiry training. To accomplish these tasks, technology teachers may wish to develop a schema to prepare and design inquiry lessons. **Figure 11-4** illustrates a practical approach that classroom teachers may expand upon. Through analyzing this schema, teachers may interpret the following:

1. The intended learning outcome of this schema is to expand the students' social/technical awareness.
2. The inquiry training process will develop the students' psychomotor and cognitive skills. This informs teachers that a hands-on and minds-on approach will be used for the inquiry lesson. The term discover is added to the inquiry learning process to emphasize that students will be involved in data gathering activities that will reveal new information to them.
3. Traditional subject matter may be part of the inquiry process. The teacher may include working with materials, techniques or processes as part of the inquiry lesson. Through analyzing modern elements of industry, the teacher may identify a problem situation for inquiry.
4. The atmosphere for the lesson will involve student interaction. This informs the teacher that students will work in groups for this lesson. By having students organized in group learning, a more technologically realistic situation can be created to solve a technology problem. The student interaction will also provide students with a social experience of sharing ideas and combining thoughts concerning the inquiry problem.
5. The problem situation developed by the teacher should include social and technical aspects. This specifically means the hands-on activity that will take place as part of the inquiry lesson will be directed at a social need or want. This schema suggests that problems relating to the construction of housing or utilization of resources are examples that could be used for inquiry training.
6. A project could be incorporated into the inquiry lesson as the basis for the inquiry. The teacher would need to be sure the project was intended to reflect the solution of the technology problem that was originally proposed to the students. If a project is to be used in an inquiry lesson, it must be flexible to allow students to conduct experiments and gather necessary data to draw conclusions concerning the problem situation.

A Schema for
Technology Inquiry Lessons

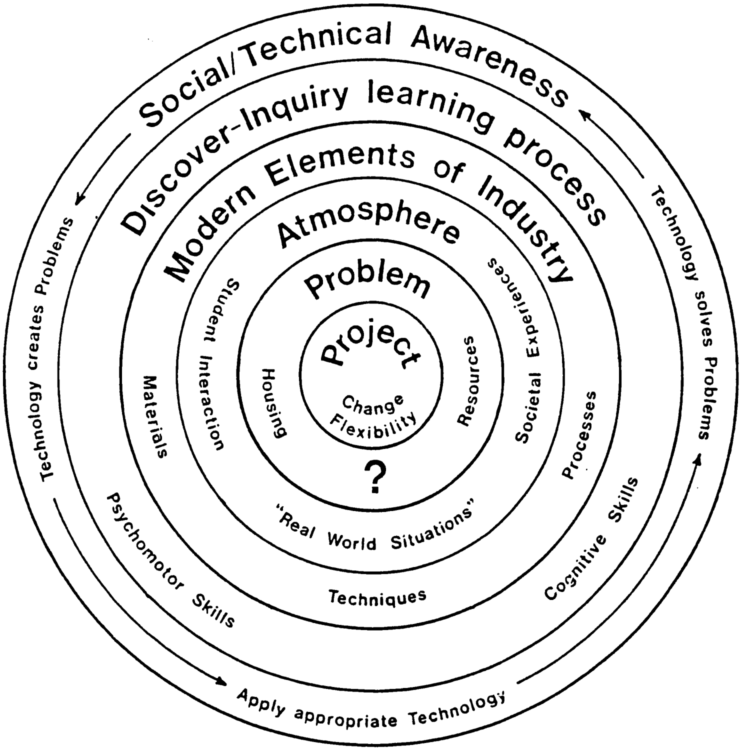

Figure 11-4: This technology inquiry schema can assist teachers in preparing and designing classroom lessons. Each level of the schema contributes to the design of the inquiry lesson. Some technology teachers may wish to develop similar schemas to follow when they use the inquiry training model.

The Learner's Role

In addition to considering the instructional preparation and design, it is important to study the learner's role in inquiry training. A teacher unfamiliar with using inquiry training in the classroom may wonder what students do to plan and participate in any inquiry lesson. It is important to consider these actions of the students.

Students that have never participated in an inquiry training lesson will need a complete explanation of the inquiry process. Those students who have been involved in previous inquiry lessons can expand upon their experiences.

In all lessons of inquiry training, students can plan by reviewing the inquiry process. Students can also practice developing good questions. The responses students obtain from the questions they ask formulate the basis for them to draw conclusions to the inquiry problem. Student planning may also involve stimulating thinking skills. Short learning units that involve reading and answering questions may help accomplish this aspect of student planning. Students may also work on their listening skills to help them comprehend input given by fellow students and the teacher during the inquiry lesson. This skill may be enhanced by students listening to audio recordings and then discussing the tapes or individually answering questions on a worksheet.

The participation of students in the inquiry lesson is somewhat determined by the pattern of inquiry the teacher identifies as most appropriate for the class. In all inquiry lessons, students will be responsible to:

1. Listen to the problem presented by the teacher.
2. Contribute to the data gathering phases by asking questions to verify the problem and conducting experiments to isolate variables of the problem.

Whether or not students will independently formulate hypotheses, draw conclusions and analyze the inquiry process is decided by the teacher. If the inquiry lesson is longer than one class session, part of the students' participation might be to conduct research outside the classroom. Students may need to use library materials, gather information from teachers in other subject areas and compile a report of their research.

INQUIRY TRAINING EXAMPLES

To further assist technology teachers in applying inquiry training in their classrooms, four sample inquiry training lessons have been developed. Each lesson focuses upon one of the technological systems: communication, construction, manufacturing and transportation. The four sample lessons are inclusive of examples that state objectives for the learning unit and provide an inquiry problem to use in the classroom. Each sample lesson also provides a description of the lesson for the technology teacher.

Sample Lesson No. 1

Technological System—Communication

Learning Unit Title—Radio Wave Transmission

Unit Objectives—

1. Students should be able to identify radio wave frequency.
2. Students should be able to conduct experiments to distinguish AM and FM frequency.
3. Students should be able to explain the process by which people communicate using the radio.

Statement of the Problem—

A family is having great difficulty receiving AM and FM frequency on their home radio.

Description of the Lesson—

This communication lesson is designed for eleventh and twelfth grade students. To accomplish the stated objectives, a hands-on approach to inquiry is necessary. Students will need to use various electronic test equipment such as oscilloscopes to view radio wave frequency. AM and FM radios will also need to be provided for students to conduct experiments. In this lesson, students will control the inquiry process because of their high maturity level. This inquiry lesson may best be conducted by having students work in groups of three or four. Grouping the students will help in classroom management and the sharing of equipment for experiments.

Three class sessions should be used to conduct this lesson. During day one, the teacher will present an explanation of the inquiry process and state the problem. The students will have until class time of day two to develop questions for the verification phase. On day two, students will be involved in data gathering. The first half of the class period will be involved in verifying the problem, and the second half of the period should provide for experimentation and testing with radio waves. The third day is necessary to provide time for students to analyze their data, create hypotheses, draw conclusions and present their answers to the class. Some time should be saved for having the groups analyze the inquiry process.

Sample Lesson No. 2

Technological System—Construction

Learning Unit Title—Development of Modular Housing

Unit Objectives—

1. Students should be able to define the concept of modular construction.
2. Students will be able to identify the need for modular housing in society.

Statement of the Problem—

An estimated three thousand people are homeless in a major United States city.

Description of the Lesson—

This construction lesson is designed for tenth grade students. There will be no hands-on learning involved in this lesson. The stated objectives will be accomplished by students who ask questions and develop a fact sheet from the teacher's replies. Since this lesson should only take one class period, the teacher will need to control the pattern of inquiry. This lesson may best be conducted by having students participate individually in the inquiry process. The conclusions students develop should be shared with the entire class. As a whole group, the class may formulate an answer to the problem. The entire class should also analyze the inquiry process so students gain a true understanding of this method to investigate problems.

Sample Lesson No. 3

Technological System—Manufacturing

Learning Unit Title—Product Quality Control

Unit Objectives—

1. Students should be able to define the term quality control.
2. Students should be able to conduct a quality control inspection of a product.

Statement of the Problem—

A toy manufacturer receives numerous letters that a new toy is faulty. The manufacturer recalls all of the toys for inspection.

Description of the Lesson—

This manufacturing lesson is designed for ninth grade students. The nature of the lesson will involve both hands-on and hands-off activities. The teacher and students will share the control of the inquiry pattern. This lesson may best be conducted by pairing students. Each pair of students will receive a faulty product to analyze. The teacher will conduct phase II through V of the inquiry process with each pair of students. Because the teacher will spend time with each pair of students, the inquiry lesson may take two or three class sessions. During the data gathering phase of inquiry, students may experiment with the faulty product to collect data to identify the problem. This lesson provides a close teacher/student relationship. Students may especially benefit from the nature of this lesson by analyzing the inquiry process with the teacher. The students should gain an understanding of the inquiry process and accomplish the stated objectives.

Sample Lesson No. 4

Technological System—Transportation

Learning Unit—Marine Transportation

Unit Objectives—

1. Students should be able to define marine transportation.
2. Students should be able to explain the concept of buoyancy.
3. Students should be able to explain how boats transport society's goods on waterways.

Statement of the Problem—

> A dock worker dropped a piece of steel in the river, and it immediately began sinking to the bottom. When he looked up, he saw a barge made of steel loaded with ten tons of coal floating down the river. He wondered why it did not sink like the piece of steel.

Description of the Lesson—

> This transportation lesson is designed for the elementary classroom. The teacher will need to control the pattern of inquiry to accomplish the stated objectives. This lesson may last one or two class periods. It is very significant that the teacher thoroughly review the inquiry process with the students. The teacher may wish to conduct the inquiry lesson so students will individually participate in the class. This inquiry lesson will not involve a lab activity. However, the teacher may provide a boat and tank of water for students to conduct experiments. At the time in which students are ready to develop hypotheses, the teacher will need to assist them in organizing their thoughts. The teacher will also need to help the entire class make conclusions and analyze the lesson.

These sample inquiry lessons that have been provided for technology education illustrate that this delivery system can be used with students in elementary and secondary schools. Other inquiry lessons can be created according to the instructional needs of the teacher. It is important that all five phases of inquiry training be included to provide an effective lesson.

SUMMARY

In an era of education when some areas of study are curtailing the use of inquiry training because of the back-to-basics movement, it seems most appropriate to utilize this model in the technology classroom. Inquiry training is a delivery system that provides the technology teacher with an organized approach to engage students in problem-solving activities. Students who are provided with the opportunity to research and experiment with solving problems develop investigative skills that are transferable to other life situations. By possessing such skills, technology students can better formulate solutions to technical and social problems that exist in our technological world.

In order for students to gain full benefit from their inquiry experiences, they must understand all five phases of the inquiry process. These phases have been identified in the chapter as: Phase I: encountering a problem; Phase II: data gathering—verification; Phase III: data gathering—experimentation; Phase IV: formulating an explanation; Phase V: analyzing the inquiry process. These five phases provide students with a procedure to analyze and formulate a rational solution to a problem.

The nature of this delivery system is an ideal instructional design for teachers to utilize in making a transition to teach technology-based lessons. Teachers will find the inquiry training model to be a motivating instructional technique. The flexibility of this delivery system allows the teacher to be very creative in applying it in the classroom setting. Most importantly, this delivery system represents the actions of a technologist and creates a learning atmosphere that illustrates technology education in practice.

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CHAPTER TWELVE

Games and Simulation

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Education is meaningless unless the teacher clearly states what is to be achieved in any given classroom. This implies that the teacher understands why technology education programs exist and can verbalize to any and all the importance and potential worth of such a program.

Equally important is the need for the teacher to be able to use the variety of instructional strategies available in the process of optimizing learning. This yearbook presents many approaches and delivery systems for the creative teacher. Games and simulation, as delivery systems, have the potential to enhance and frequently make very real a learning circumstance.

Technology education teachers have employed games and simulation since the very early days of industrial arts. In many cases the teacher was aware that what students were experiencing was good, but unfortunately, was unable to academically associate the activities with a larger holistic plan which could optimize the process of learning. Consequently, all too often such activities were viewed by others in the school as nothing more than frivolous waste of student time and potential.

Such perceptions need to be turned around. Today technology education has the potential to deliver the most relevant and necessary curriculum in the history of education. First, it is necessary to believe this is possible. Next, people need to understand technology education as a discipline and know what it can do for the future of all who experience the curriculum. Teachers need to understand what sorts of goals ought to be created for students, and finally instructional strategies must be designed in such a way as to insure that stated goals are being realized.

Games and simulation are but two of many delivery systems which can be employed to facilitate the learning process. If properly understood and designed, the techniques built into games and/or simulation can facilitate learning at the upper levels of the cognitive and affective domains of learning. (See Chapter Two for further information on the domains of learning and the levels of learning within the cognitive domain.)

OBJECTIVES

After completing this chapter, the reader will be able to:

1. Verbalize the component elements of the cognitive and affective domains of learning and relate their importance to the design of games and simulation.
2. Define simulation.
3. Define games.
4. Define systems as the term applies to communication, construction, manufacturing and transportation.
5. Verbalize the term holistic as it relates to technology education systems.
6. Determine the importance of designing games and simulation in keeping with higher order process skills holistically integrated with technological systems.

GAMES AND SIMULATION: RELEVANT UNDERSTANDINGS

Gareth Branwyn (1986), writing for the *Futurist,* presented a discussion on the potential of gaming. He indicated:

> The past decade has brought advances in the techniques and applications of games/simulations to a point where a gaming "science" is emerging. These developments, coupled with advances in simulations technology (computers, improved audio-visual technology and simulators), could have far-reaching effects on future educational and training methods (p. 29).

He later indicated:

> . . . we are developing into a world that moves at electronic speeds. Technology is giving us the means to simulate environments of any space or time. It is likely that we will spend increasing amounts of time in these artificial realities in both our work and our leisure. They will allow us to interact with the past, the present, and the future: to role play different cultures and value systems; and even to attempt survival in a world with different laws of physics and nature (p. 35).

What is the meaning of some of the terms mentioned in the discussion so far? Technology, systems, games and simulation have been used without adequate definition. The definitions which follow are presented in terms of how they may be interpreted in keeping with the topic of discussion.

The Association for Education Communications and Technology (1979) offered help in defining certain terms including games, simulation, systems and technology.

Games and simulation are specially designed activities providing 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. This leads students to active assimilation of information in order to carry out action toward relevant goals.

They suggest that one part, *gaming*, is an educational technique in which the student is presented with a situation involving choice in which there are differential risks. Customarily, the choices are made in a simulated real life situation and the situation changes dynamically as influenced by the choices, which then produce some type of payoff, such as a reward or deprivation, dictated either by chance or by a choice of strategies made by the student.

Simulation is defined more specifically as: (1) a learning process which involves pupils as participants in role presentations and/or games simulating life situations or environments and (2) a learning activity which makes the practice and materials as near as possible to the situation in which the learning will be applied.

A *system* can be defined as the structure or organization of an orderly whole, with interrelationships of the parts. *Technology* includes processes, systems, management and control mechanisms (both human and non-human), and above all, a way of looking at problems as to their interest and difficulty. The feasibility of technical solutions and the economic values—broadly considered—of those solutions are also a part of technology.

DeVore (1980) described technology as follows:

> The study of the creation and utilization of adaptive means, including tools, machines, materials, techniques, and technical systems, and the relation of the behavior of these elements and systems to human beings, society, and the civilization process is the field of study known as technology (p. xi).

Orlich (1986) also helped to explain simulation. He suggested that simulation is the presenting of an artificial problem, event, situation or object that duplicates reality (a technological reality), but removes the possibility of injury or risk to the individuals involved in the activity. Simulation provides a model of what exists or might exist in a set of complex physical or social interactions. Simulation is a representation of a manageable real event in which the learner is an active participant engaged in learning a behavior or in applying previously applied skills or knowledge.

Orlich discussed the differences between games and simulation. He suggested that if there is a difference it is that games are played to win and in simulation a winner is not a necessity. He further differentiated between the two in suggesting that games will more easily be applied to the study of issues rather than processes.

Greenblat and Duke (1981) suggested that simulation entails abstraction and representation from a larger system. Central features must be identified and simplified, while less important elements are omitted from the model. It is the very process of highlighting some elements and eliminating others that makes the model useful. They described the conditions of gaming by indicating that the term "game" is applied to those simulations which work wholly or partly on the basis of the players' decisions. This is because the environment and activities of participants have the characteristics of games. Players have goals, sets of activities to perform, constraints on what can be done and payoffs (good and bad) as consequences of their actions. The elements in a gaming situation are patterned from real life—that is, the roles, goals, activities, constraints and consequences and the linkages among them simulate the real world (p. 33).

The line between games and simulation is a bit fuzzy. In a simple form, games will reflect a reward and/or punishment circumstance. Very sophisticated simulation models are designed to engage total technological systems scenarios which encourage problem solving, critical thinking and higher level processes skills.

RATIONALE FOR GAMES AND SIMULATION

Simply stated, games and simulation are method oriented tools technology education teachers may employ to achieve educational goals. Rationale for use lies in a clear understanding of what the game or simulation is designed to achieve in terms of student outcomes and the correlation of those objectives with the goals and objectives of the technology education program. A brief review of some past, present and future educational goals appears in order.

It has been indicated that games and simulation, properly formatted, can impact on higher level cognitive and affective skills development in students and subsequently lead to the organization of personal value systems. It can be further assumed that student interaction in games and simulation will lead to more clearly defined value systems.

A study by Finch and O'Reilly (1973) found that a simulator was considered effective in teaching troubleshooting, especially with regard to problem solving strategy development. They also concluded the simulation provided positive motivation, developed confidence, provided realism, was easy for students to use, had excellent transfer potential to real world problems and in general enhanced the learning process (pp. 49-56).

Heitzmann (1974) concurred with the findings of Finch and O'Reilly in stating that simulation will teach problem solving skills. He went on to conclude that simulation involving problem solving tasks could develop in students an ability to apply (transfer) knowledge of concepts and principles. This in turn leads to a real payoff in the affective domain which facilitates attitudinal change in keeping with the teaching of values (pp. 18-19).

Higher level cognitive and affective level skills will be necessary to survival. **Figures 12-1** and **12-2** (p. 188) illustrate the taxonomies of Bloom (1956, pp. 62-200) and Krathwohl (1964, pp. 95-175) relative to the cognitive and affective domains. The teacher who can combine the higher levels of these taxonomies with a systems understanding of the taxonomies basic to technology education can begin to develop instructional materials which ultimately will take on holistic characteristics. Carefully designed games and/or simulation can contribute significantly to the enhanced potential of technology education students.

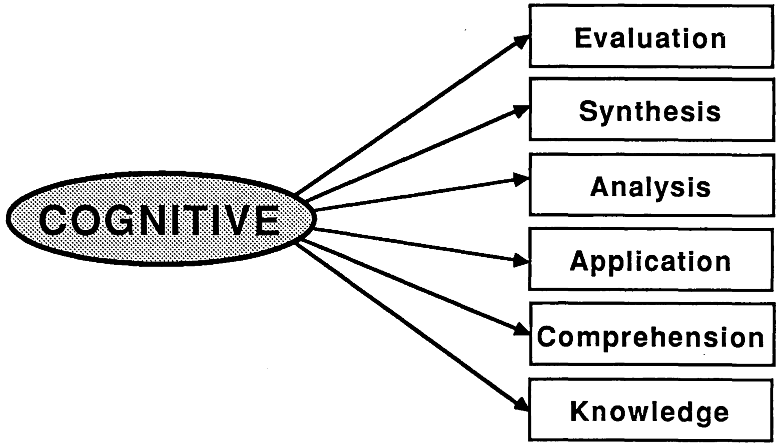

Figure 12-1: The cognitive domain is subdivided into six levels. The lower levels must be taught before moving to the higher levels.

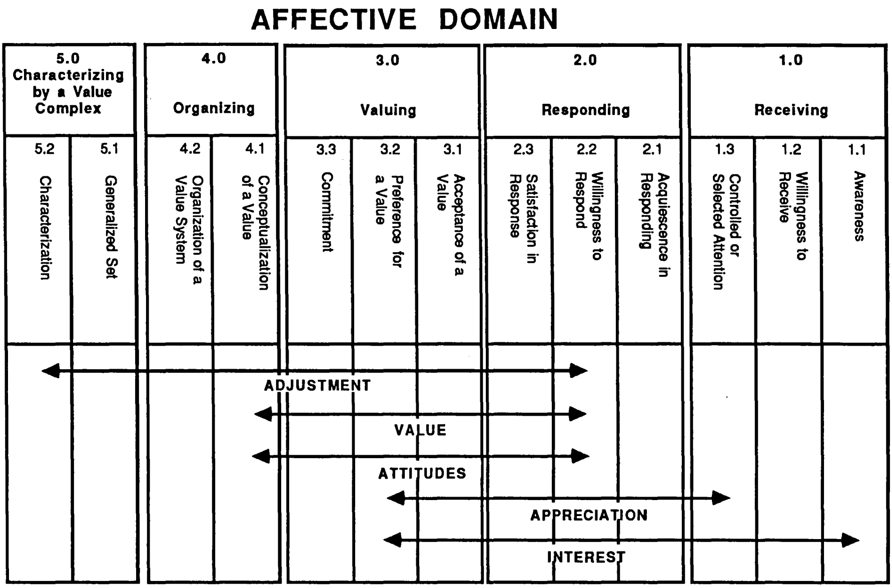

Figure 12-2: The range of meaning, typical of commonly used affective terms, measured against the Taxonomy continuum.

PURPOSES OF SIMULATION AND GAMES

One of the few recent discussions of simulation and games as delivery systems comes from Donald Orlich. In his discussion on purposes he offers the following advantages:

1. Develop changes in attitudes.
2. Change specific behaviors.
3. Prepare participants to assume new roles in the future.
4. Help individuals to understand their current roles.
5. Increase the student's ability to apply principles.
6. Reduce complex problems or situations to manageable elements.
7. Illustrate roles that may affect one's life but that one may never assume.
8. Motivate learners.
9. Develop analytical processes.
10. Sensitize individuals to another person's life role (1985, p. 307).

Orlich further indicated that learners as a result of simulated activities, are stimulated to learn more and perceive that knowledge acquired in one context is valuable in other situations. Here is found the elusive concept of "transfer." In reference to the taxonomies of Bloom and what students become involved in, Orlich indicated involvement with application of principle, analysis of trends, synthesis of information and evaluation of alternatives as cognitive objectives at the higher level of the cognitive domain. On the affective side (Krathwohl's taxonomy) good design of simulations raises questions requiring value oriented responses. He indicated that, collectively, there are thousands of ways of incorporating games and simulation into classrooms. With a little thinking one could list a dozen strategies from his/her own field of specialization (p. 313).

According to Duke (1974), games and simulation have tremendous potential in developing a future orientation in youth. The gaming/simulation delivery system will have a series of scenarios depicting possible courses of action. Students become decision makers, acting out prescribed roles. As a result of acting out "what if" situations, alternative futures can be explored (p. 49).

In terms of purpose, Duke (1974) identified four reasons why gaming/simulation might be employed. The first of these he refers to as dialogue intending "to increase communication among a group about a topic which is complex, future oriented, of a systems nature and which requires a vocabulary or vernacular which is not commonly shared by the group at the onset of the discussion" (p. 78).

A second purpose is to project information in an academic context. This he indicated was the prime focus of games available at that time.

Extracting information or opinions is a third purpose of games/simulation. This he sees as a more powerful technique in that opinions and individual responses to problems are solicited.

Finally, Duke indicated that games/simulation are good motivational devices and are destined to fail if their design is such that it does not stimulate even recalcitrant audiences (pp. 79-81).

Brawnyn (1986), an advocate of gaming, promoted it as one of the most sophisticated forms on the communication continuum because it can handle a multiplicity of languages, communication technologies and patterns of interaction (p. 31).

He went on to say:

> This ability of games/simulations to convey a "gestalt" using integrated communication forms has been referred to as a multilog. As our world becomes increasingly complex and our problems blend together from black and white to mutable grays, such a form of multilog may prove essential in order to gain a greater understanding of the tangled web of critical issues—and their potential solutions (p. 31).

The discussion to this point has taken us far beyond traditional concepts of technology education. Games and simulation continue to be appropriate in teaching sub-concepts or micro-segments of a larger system. What is important, based on data presented to this point, is that the teacher be able to directly associate the micro experience with the larger picture.

It should also be clear that games/simulation reach beyond a computer generated simulation of a 747 jetliner. Technology education by definition takes on interdisciplinary meaning. Consequently, the best of games and simulation will likely reach into a diversity of disciplines for probable scenarios. The need to be ever conscious of higher level cognitive and affective domain objectives in game design is critical to the welfare of the youth we serve.

CURRENT APPLICATIONS OF GAMES AND SIMULATION

Perhaps all of us know of the diversity of simulation associated with our space program. Zero gravity and space walks took place on earth long before astronauts set foot on the moon. Simulators have been used in many ways to prepare astronauts for travel in space.

The pilot who guides the DC-10, 747, or 757 spent many hours in perfect mock-ups of those plane cabins. A diversity of environments, weather conditions and technological problems are programmed into the simulator and will develop a pilot to the point where his/her first "live" flight may be a regularly scheduled commercial one, complete with passengers (Branwyn, 1986, p. 32).

Krouse (1986) described some "state of the art" developments in CAD/CAM (Computer Aided Design/Computer Assisted Manufacturing). In this field the technology is evolving so rapidly that obsolescence could become a capital intensive problem. Programs today contain packages which simulate mechanical behavior so that design engineers can check the movement of linkages and structures on a graphic display.

This appears to be only the tip of the iceberg in terms of what industry is doing today using computer generated models, integrated plant design and manufacturing, plus more. Perelman (1986) related that the combination of computers and optical storage devices (videodiscs) has already been applied successfully to industrial and military training (p. 16).

In the world of business the "think tank" model (simulating present and future alternatives) has proven to be an extremely valuable tool in forecasting probable futures. This simulation of reality is attractive because it allows for the creation of a manageable version of the realities of life. "This ability to model options without interfering with the real world has attracted the attention of corporations and government organizations wanting to 'imagineer' new directions" (Branwyn, 1986, p. 32).

The "War Room" or situation room is another example of a gestalt communication mode. Input can come from a diversity of sources and the integration of this input generates choices and perhaps some "if then" options (Duke, 1974, p. 48-49).

Recent events in nuclear power plants are also fostering simulation. Operators in many cases must now complete a computer simulated nuclear plant program prior to going to work. Duke (1974) presented a persuasive argument for games and simulation and their ability to engage complex real world problems when he said:

> Whenever large numbers of people wish to become involved in complex problems, there is no alternative but to seek new modes of communication. The average human has the ability to deal with complex phenomena when they are presented in a coherent context. We need not suffer the hazards of depending on an elite unless we are unable to find expedient devices for introducing the citizen to complexity. It is only when we dichotomize, specialize, and truncate that the citizen falls by the wayside. We must rely on the intelligent consensus of a broad citizen base if we are to sustain democracy and if we are to avoid regression to a primitive state where, like the naked ape of our past, our world is controlled by distant and obscure gods, sole masters of the technology that surrounds us. Man must learn to control his destiny. To do so he must manage both uncertainty and complexity (p. 172).

Perhaps some carefully designed games/simulation created by technology education teachers can begin to address the questions raised by Duke.

GAMES AND SIMULATION IN TECHNOLOGY EDUCATION

It is not the purpose or intention of this discussion to identify and/or evaluate existing developments. As Duke (1974) concluded:

> There are several published sources which catalogue available games. These are heroic efforts by the authors to identify, locate, abstract, organize, and present in abbreviated form some statement about the material available. While the efforts are valuable, they fail to fulfill their intended purpose . . . (p. 155).

The reasons for failure are diverse and include everything from an inability to assign a good simulation activity with a disciplinary base to a lack of agreement regarding how effectively they meet measurable goals.

Creative technology education teachers have incorporated games and simulation for decades. Perhaps the best known activities incorporating games and/or simulation are the classroom activities developed for the *World of Construction* (Lux and Ray, 1970) and the *World of Manufacturing* (Lux and Ray, 1971), also known as the Industrial Arts Curriculum Project (IACP).

The World of Construction simulated surveying activities, collective bargaining, micro construction activities to include steel erection, concrete mixing and a residential module complete with plumbing and wiring. Students also built a model dream house and briefly engaged the concept of community planning.

In the World of Manufacturing students engaged the concept of manufacturing with everything from design, to prototypes, to production and quality control to marketing and distribution of a product. This does not imply that the Industrial Arts Curriculum Project materials ought to be revived, but rather to show that there have been some good examples to use as jumping off points. More recently Wright and Henak (1985) introduced similar activities in a production context.

In the classrooms of today we have access to much more sophisticated technology in our CAD systems, our robots, our computerized and numerically controlled machines plus an opportunity to develop a simulated version of modern manufacturing. Fundamental to any of this activity is the need for us to reflect on why we are doing this and also why we have elected simulation as a delivery system.

In other technological systems there is further opportunity to employ the use of games and simulation. A number of games and simulation already exist relating to community planning and the concept of the city. Some of this is good and might well be used in the technology education classroom. A good model might incorporate the need for innovative transportation and communication opportunities integrated holistically with the total concept of the city.

Finally, if one sincerely believes in communicating the concept of technology education he/she needs to think in terms of systems and the need for youth to understand the macro. **Figure 12-3** illustrates the well known input-process-output-feedback model necessary to understanding systems. Games and simulation can do much to help us achieve these goals.

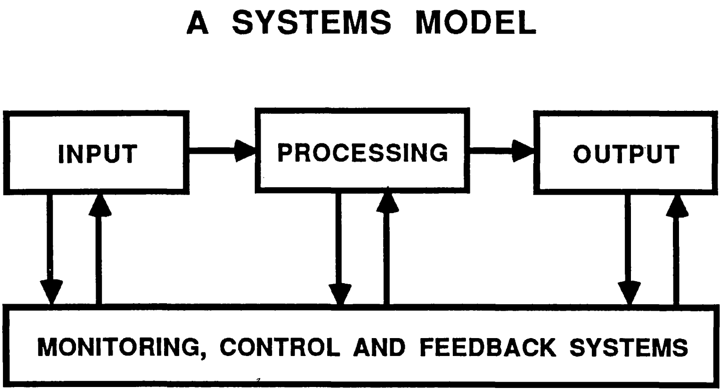

Figure 12-3: A model to help understand the thought process in technical systems.

DESIGN, DEVELOPMENT, MAINTENANCE AND COST

Where do games and simulation belong in a technology education program? Can the classroom teacher effectively develop worthwhile games and simulation? From an instructional strategies point of view, is this the appropriate path to take?

The answers to these questions do not have definitive responses. Rather, questions raise other questions related to goals, objectives and functions of the technology education curriculum. Who will be served by this curriculum? Is the program so designed that it could serve pre-K through the geriatric set? If so the opportunities are infinite.

The Orlich materials identify three major types of simulation:

> (1) human simulation, which includes role playing; (2) person-to-computer simulation which is slowly increasing in use; and (3) computer to computer simulation which is the most sophisticated and complicated type and is currently used to generate global or whole earth models. The third type may be used by students when they enter the professional world as researchers or business leaders (1985, p. 308).

It can be persuasively said that all types have places in technology education programs. The first order of business is to establish the desired learning outcome of a particular activity. This will hopefully address the higher order processes apparent in the cognitive and affective domains.

Regarding the development of problem-solving skills, Orlich (1985) suggested that the problem-solving mode seems to be partially characterized by the amount of information shared by the players. When there is little information about the other players' strategies, extreme competition and lack of trust often result. This is typical of games in which players from the start see one another as having opposing interests. When more information is shared, players begin to perceive common interests and are more likely to build alliances and trusting relationships. The building of these alliances in the process of seeking collective solutions to technological problems is wide open to exploitation by technology education teachers and their students. Orlich said it is easy to design one's own simulation or game. Citing Gordon, he offered the following general design rules that might be helpful:

1. Define objectives.
2. Determine the scope of the game in terms of the issues to be examined, the setting in time and the geographic area.
3. Identify key actors in the process, whether individuals, groups, organizations or institutions.
4. Define the objectives of the actors, in terms of wealth, power, influence and other rewards.
5. Determine the actors' resources, including the game information each receives.
6. Determine the decision rules, or criteria, that actors use in deciding what actions to take.
7. Determine the interaction sequence among the actors.
8. Identify external constraints on the actions of the actors.
9. Decide the scoring rules or win criteria of the game.
10. Choose the form of presentation (board game, role-playing) and formulate sequence of operations.

This set of rules with a few language changes is also promoted by Heitzmann (1974, p. 15) who makes a case for teacher designed instructional materials. They would then be commensurate with specific curricular materials.

Orlich provided us more help in the game design process sharing a model developed by Maidment & Bronstein. This is illustrated in **Figure 12-4** on the next page.

Richard Duke indicated that the game design process has perhaps been reinvented as frequently as the wheel. His overall design process is considerably more specific and sophisticated. There are four phases

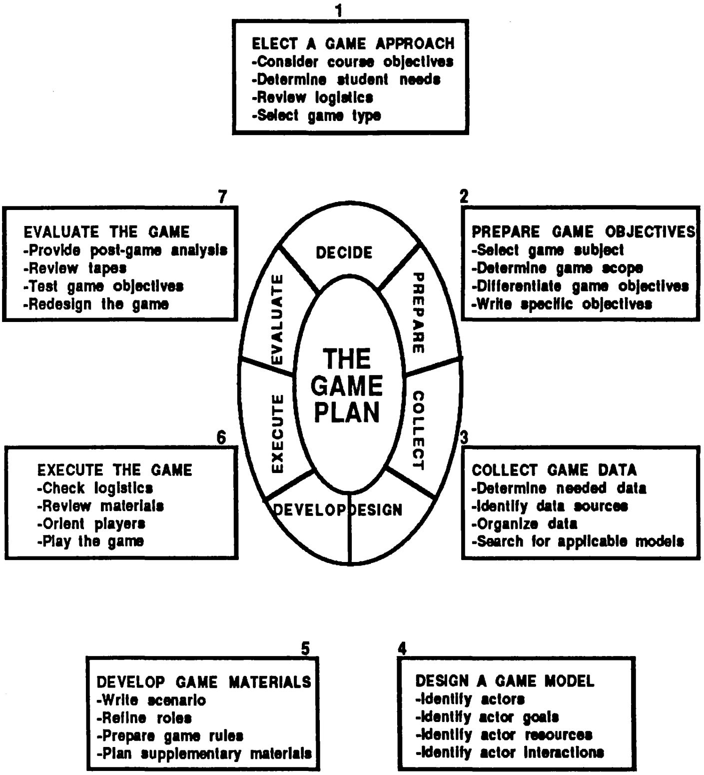

Figure 12-4: A Design and Use Cycle for Games or Simulations. (Source: Robert Maidment and Russell H. Bronstein, *Simulation Games; Design and Implementation* (Columbus, Ohio: Charles Merrill Publishing Company, 1973. p.57. Used with the written permission of Charles Merrill Publishing Company. 1985, p.318.)

of game design: (1) initiation, (2) design, (3) construction and (4) evaluation (Greenblat and Duke, 1981). He recommended the following procedure:

1. Develop written specifications for game design.
2. Develop a comprehensive schematic representation of the problem.
3. Select components of the problem to be gamed.
4. Plan the game with the Systems Component/Gaming Element Matrix.
5. Describe the contents of each cell (4, above) in writing.
6. Search my "repertoire of games" for ideas to represent each cell.
7. Build the game.
8. Evaluate the game (against the criteria of 1, above).
9. Test the game in the field, and modify (p. 64).

The Systems Component/Gaming Element Matrix mentioned in number four above is the heart of the developmental process. Duke further indicated:

A game/simulation consists of twelve basic elements:

1. Scenario.
2. Pulse.
3. Cycle sequence.
4. Steps of play.
5. Rules.
6. Roles.
7. Model.
8. Decision sequence and linkage.
9. Accounting system.
10. Indicators.
11. Symbology.
12. Paraphernalic (p. 65).

To describe in detail the function of each of these elements would require extensive and descriptive dialogue reaching beyond the intent and scope of this chapter. For the serious designer of games and simulation, a thorough study of the work of Duke is strongly recommended.

Depending largely on the paraphernalia, games and simulation can demand a significant capital investment. If current technological options (computers, lasers, robots, fiber optics, video discs, plus other devices) are deployed, the maintenance and upkeep (and updating) could be significant in terms of down time and/or dollars.

Are games costly? Answers may vary a great deal. Duke suggested that games are one of the most expensive modes of communication. The expense of gaming has not yet been clearly acknowledged, but would be revealed dramatically if it were really possible to do cost benefit analysis, especially in consideration of the widespread misuse of gaming.

Has this argument been eroded since it was written? Have new technological options added to or subtracted from the cost-effectiveness of games and simulation? We do know that industrial simulation (pilot and astronaut training, nuclear plant operator training, etc.) are considered very cost effective. We also know that capital investments in technology education programs are being viewed more critically than ever before. Perhaps the options of games and simulation can respond to budget scrutiny. The words of Perelman appear worthy of serious consideration: "Out of sheer necessity, the demand for cost-effective instructional technology is about to explode" (1986, p. 14).

This quest for cost effective simulation programs continues today. Ploch (1986), writing for *High Technology* magazine, indicated that the writing of high quality software for a simulation program for an eight-bit computer might cost $500,000. Good software for a semester program might cost $1-1.5 million (p. 47).

OTHER CONSIDERATIONS - INCLUDING CAUTIONS

Technology today can do much to enhance the intellectual development of youth. New instructional techniques can "harness the power of multiple technologies, satellite delivered instructional programming, laser discs, computers, videocassettes, and closed-circuit television" (Larick and Fisher, 1986, p. 21). They suggested also that current trends point to the continued growth of information as a valuable resource that can be stored, retrieved and shaped for educational use through technology. Information technology and education can be linked to create a "preferable" future in a school district.

Caldwell (1986) supported the position that technology has great potential for the teaching of thinking, and problem solving. He indicated:

> By their nature, computers are tools for problem solving, which is actually a subset of the human thinking process. In one respect, the whole point of having a computer is to use it to build models, create simulations, facilitate decision making and use information in a variety of ways (p. 14).

Wasserman (1986) did not view the computer in such a favorable light. He suggested that it is difficult to learn interpersonal functioning when each child is sitting at a computer console, working on spelling or mastery of algebra.

Branwyn (1986) also called attention to concerns with less than desirable ramifications of technology. He suggested that researchers have raised serious questions about the psycho physical effects of prolonged exposure to cathode-ray-tube displays. Hyperactive stimulation, inducement of epileptic seizures, headaches and nausea have been reported. And critics argue that, as the computer continues to be used for educational and recreational functions, less time is available for human-to-human interaction. His conclusion is worth noting:

> Future computer games/simulations need to be designed to stimulate interest in the real world and/or require the "human element" in achieving game goals (p. 35).

Assume for a moment the computer has the potential to be considered an overall positive option supporting the development of games/simulation. As this is being written there is in U.S. schools one computer for every 50 students. The majority of these machines are old, slow, have little storage capacity, are poorly used and have questionable or poor software (Ploch, 1986, p. 44).

Ploch made an additional observation significant to the potential of computers for games and simulation. Because these machines have limited memory (64 kilobytes) and 8 bit microprocessors, the kind of software which can be run will of necessity be less challenging (p. 45).

Evaluation

The question of accountability in education is more prevalent today than ever before. As teachers move toward greater use of games and simulation, the related activities enjoyed by students will increasingly be questioned as to academic worth. The case has been made for writing process-oriented behavioral objectives in keeping with the taxonomies of Bloom and Krathwohl.

Evaluation instruments for determining the success or failure of games and simulation to meet stated objectives have been designed. They range from devices for recording game information to a general framework for evaluation and a checklist for evaluation—all provided by Greenblat and Duke (1981, p. 247-252). Other examples can be found in Orlich (1985, pp. 330-332). Teachers employing games and simulation will probably decide that personally designed evaluation devices are best. They will be specific to the program employed and should reflect the achievement of process oriented behavioral objectives.

SUMMARY

Games and simulation have the potential to enhance technology education. Being able to verbalize a technology education program is basic and fundamental to any curriculum development. The subsequent design of a delivery system and the choice of method should be based on clearly articulated goals for the program.

The teacher must place emphasis on understanding all systems—the technological, sociological, ideological, ecological and the interrelationship of these systems to human purposes (DeVore, pp. 316-318). A new form of literacy—a technological literacy—should be required of all students in addition to the basics of reading, writing and computation (p. 338).

Carefully designed games and/or simulation could be responsive to some of the needs outlined by DeVore. Some of the pluses coming from good programs and techniques will be students who are technologically literate, have the skills of inquiry, problem solving, decision making, critical analysis and the ability to conceptualize problems holistically.

The closing line belongs to Orlich:

> With inquiry, you can generate enthusiasm among the students in your classes. You can inspire individuals to discover, to question, and seek. You can break the monotony of dull classes by using interactive simulations or games. You control the learning environment. Structure this environment so that everyone in it will be highly motivated and successful in learning. It is the very least you can do or, perhaps, . . . the very most! (1985, p. 330).

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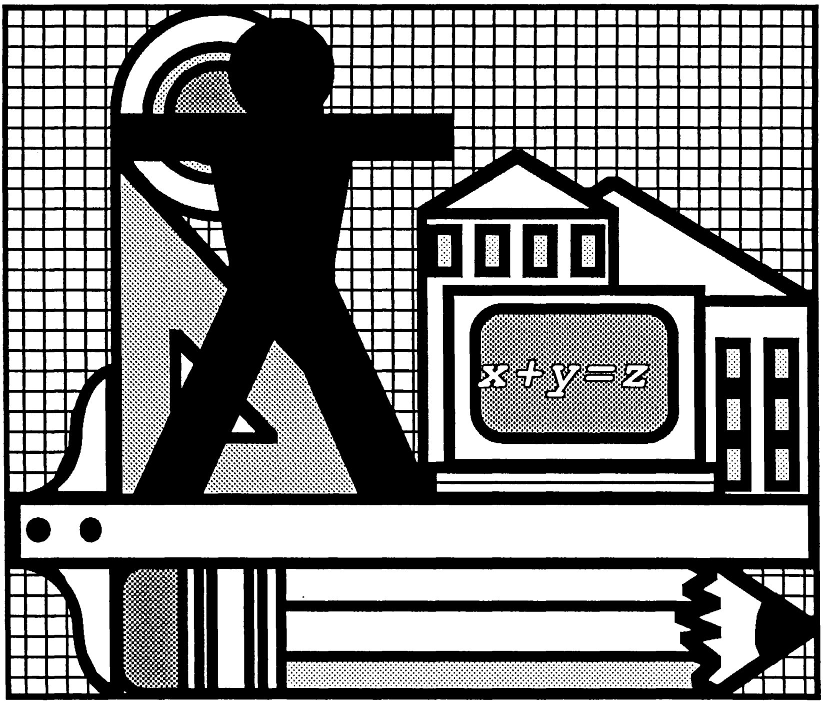
SECTION 4:



SUMMARY & REFLECTIONS

CHAPTER THIRTEEN

Summary and Reflections

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SUMMARY

Technology education has become more and more accepted in American schools during the past decade. This movement has developed because of the need to understand our technological society. Technology is advancing at a very rapid rate and, therefore, it is becoming more important for all American citizens to become technologically literate. Technology education has established as one of its major goals to contribute toward making a technologically literate society. Coupled with this move is the need to examine and develop new instructional strategies. This yearbook has attempted to define and describe several ways in which preservice and inservice teachers can change their teaching methods to respond more effectively to the needs of technology education.

The instructional strategies contained in this yearbook have been divided into "Approaches to Teaching Technology Education" and "Delivery Systems for Teaching Technology Education." These types of instructional strategies are designed to help the technology teacher teach in all three *learning domains* of Bloom's taxonomy: psychomotor, cognitive, and affective. It is critical that technologically literate citizens have psychomotor skills, but they must also be able to function at the higher levels of the cognitive domain and develop sound and justified attitudes about advancing technology.

In order for technology teachers to become effective facilitators of learning in the classroom and/or laboratory, they must be sensitive to *student needs*. Understanding the psychological needs of students will help the technology teacher in selecting the most appropriate instructional strategies for use in the classroom. Student needs that are met help to develop a more positive attitude about learning and technology. On the other hand, if student needs are not met, more negative attitudes about both learning and technology seem to develop.

When professionals in our field analyze what is needed to improve technology education curricula various goals begin to emerge. For example, it is generally agreed that to teach technology education effectively, *concepts* must be emphasized. With the rapid change in technology, it is virtually impossible to remain current with all of the technological developments. So what does a teacher do when the technical scene constantly changes? The answer may be to teach concepts. Concepts contained within the technological systems remain rather constant even though the specific technology changes rapidly. Once a technology teacher learns how to identify important concepts, the process of teaching a rapidly changing technology becomes easier.

Technology today is highly *interdisciplinary*. This means that no discipline exists by itself. Everything is interrelated. Technology interrelates with mathematics, natural sciences, arts, social sciences, journalism, business, and other curricula. Ignoring these relationships would certainly give the technology student of the future a rather narrow and inaccurate view of technology. The integration of several disciplines in the teaching of technology education is somewhat different from the traditional teaching style in which only one subject is taught in a classroom. To effectively teach about technology, teachers must incorporate this approach in their classrooms and laboratories.

A rather new approach to teaching technology education is called the *social/cultural* approach. There is a high degree of interaction in our society between humans and technology. An understanding of the relationship between humans and their technology is essential for technology students. Imagine citizens going into the 21st century not understanding the relationship between technology and their lives. Any technology education teacher would be short-sighted if the social and cultural impact of technology were not studied.

The future technology student must gain the confidence and the critical thinking skills necessary to understand and control technology. A technology student who is not able to look at technological problems and seek their solutions will not be technologically literate in the 21st century. *Problem solving* has been identified as a major skill necessary to deal with technology. Someone who can solve problems is able to control technology; those who cannot must let technology control them. When one considers the ramifications of the latter choice it becomes obvious that problem solving must be an integral part of technology education programs.

Within technology education different *technological systems* are used to break the content into logical areas. These systems are communication, construction, manufacturing and transportation. Other organizers are used; however, they are not as common as these four. An interesting approach is to integrate the four systems of technology in the classroom and laboratory. Teaching from this approach helps technology students see the relationships between all systems. For example, could airplanes function without being supported by a massive communication system? Could transportation systems be built the way they are without a manufacturing system? This is an innovative way in which teachers may approach the content of technology education, suggesting that all technologies be studied as they relate to one another.

The *interpretation of industry* approach utilizes developments from some programs introduced a quarter of a century or so ago to make a significant contribution to the teaching of technology education. Many of the past programs centered their content around the concept of an industrial structure. The students designed, manufactured, marketed and serviced products. In addition, the classes organized and functioned much like an industry. This approach gives the student a broader appreciation of technology education. Without considering this approach the student may be slighted and not have a well rounded knowledge of technology within our society.

The technology teacher should try to include these six instructional strategies—"Approaches to Teaching Technology Education"—in his/her teaching. The more approaches used, the more likely the student will become technologically literate.

The second type of instructional strategy discussed was "Delivery Systems for Teaching Technology Education." Delivery systems are the actual methods used in teaching technology education. Delivery systems help the teacher transmit the information to the students.

Delivery systems that continue to be necessary in technology classrooms are *lectures* and *demonstrations*. Technology content can be presented to the students very efficiently and effectively through their use.

When studying the social and cultural aspects of technology, *cooperative group interaction techniques* may be the most effective delivery system. Students can be placed in groups to help solve technological problems or develop creative solutions. When students work in small groups to solve technological problems, many times they learn much more than a teacher realizes. The teacher, in this case, becomes a facilitator of learning rather than merely a dispenser of information and facts.

Another skill needed by the student who enters a technological future is that of *inquiry*. Inquiry techniques, such as *discovery* or *experimentation*, will be necessary for a person to function in the 21st century. Inquiry is a delivery system in which students are given a chance to investigate various technological concepts and ideas. The teacher arranges the inquiry experience so that the student develops essential learning about technology. Several models of inquiry are available to show how this delivery system can be incorporated in the technology education classroom.

The technology teacher must also be familiar with *games* and *simulation*. These are delivery systems in which a form of technology is simulated or presented as a game in the classroom. Rather than providing the complete technological component in the classroom the technology teacher simulates the component. For example, a computer program may simulate a drag race. The students can change engine size, tire size, weight of vehicle and gear ratios based upon a simulated drag race. *The World of Construction* and *The World of Manufacturing* (IACP), a program developed in the 1960's, included many simulated experiences.

Obviously, all of these approaches and delivery systems cannot be used all of the time. However, it is important to try to use as many as possible, selecting those which appear most effective for the topic being studied. In order for technology education to be successful, these and other instructional strategies must be used in the laboratory and classroom. The more instructional strategies that are used, the better the chances the teacher has of accomplishing the goals of technology education. The best way to look at the approaches and delivery systems in this yearbook may be to refer to **Figure 13-1**. In this figure, the arrow represents the path that the technology teacher should follow to achieve excellence in instruction. The technology teacher should always try to improve his/her instructional strategies. Obviously, no teacher will ever find a solution to all problems! But if technology education is to succeed as a discipline, teachers must constantly aim in the right direction in an attempt to achieve the **End Goal** (becoming the most effective and efficient facilitator of learning). Achieving this End Goal is possible if today's technology teacher incorporates the contemporary instructional strategies discussed in this yearbook.

INSTRUCTIONAL STRATEGIES FOR TECHNOLOGY EDUCATION

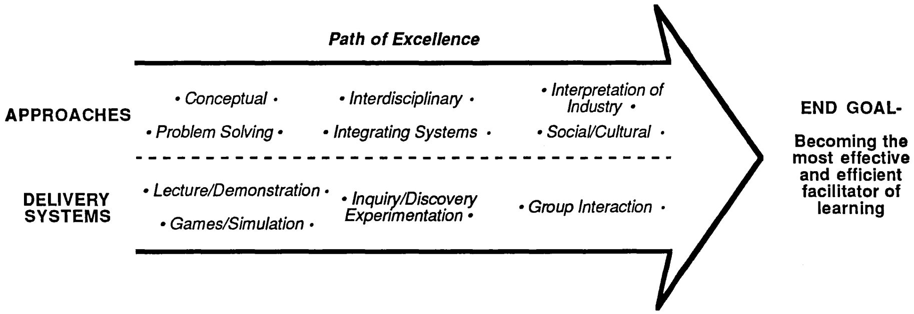

Figure 13-1: Technology Education teachers should use as many approaches and delivery systems (intertwined) as possible to achieve the "END GOAL."

REFLECTIONS FOR THE FUTURE

Any developing discipline needs strong research to support it. In the field of technology education much work remains to be done in instructional strategies. Research is necessary to establish in-service systems for those teachers who can't attend state and national conferences. This in-service network should provide both content and new instructional strategies in technology education.

A second area that requires more research in instructional strategies is disseminating ideas, methods, devices, etc. that have worked in the secondary classroom. Many secondary school teachers are doing an exemplary job of teaching technology education, selecting the most appropriate instructional strategies and incorporating innovative teaching styles. These must be made known to the teachers who need help in this area. A major research project is needed to design and implement a model to help disseminate noted and successful instructional strategies for technology education.

A third area that will require additional research is preservice education. The research completed for this yearbook revealed a need for more contemporary information on instructional strategies provided by colleges and universities. Research is needed to identify ways to update college "methods of teaching" courses which show preservice technology education students how to use improved instructional strategies.

If these areas of research are addressed in the near future, technology education will have a better chance of developing, growing and becoming more accepted.

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