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IMPLEMENTING TECHNOLOGY EDUCATION

1986

American Council on Industrial Arts Teacher Education

35th Yearbook
IMPLEMENTING TECHNOLOGY EDUCATION
IMPLEMENTING TECHNOLOGY EDUCATION

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35th Yearbook, 1986

American Council on Industrial Arts
Teacher Education
During the past five years the discipline of industrial arts has experienced significant change. Much of this change was prompted by the Jackson's Mill Industrial Arts curriculum project which provided a new curriculum theory. This effort was followed by many other significant events which have altered content and instructional strategies in many programs at all levels. In 1985 the American Industrial Arts Association changed its name to the International Technology Education Association. The long-range plan of the ITEA (1986-1990) calls attention to the need for technological literacy and sees Technology Education as the discipline to provide such education.

"Yearbook 35" comes at a logical time in the midst of the call for new models to replace industrial arts. This book takes curriculum theory and translates it into action. Implementation strategies are identified at all levels: elementary, middle/junior high, secondary, teacher education, and graduate level. The reader will find useful information to design and carry out unique programs in Technology Education. This information is provided by individuals in the discipline who have designed and implemented successful programs.

The Council commends Ronald E. Jones and John R. Wright for their monumental contribution to the profession. This Yearbook will make a vital contribution to the new thrust in the educational system, that is, Technology Education. The Council also recognizes Bennett and McKnight for its continued support and contribution by publishing this Yearbook.

March 1986

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President, ACIATE
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Yearbook Proposals

Each year, at the AIAA international conference, the ACIATE 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, and sent to the committee chairman by February 1 of the year in which the conference is held. Below are the criteria employed by the committee in making yearbook selections.

ACIATE Yearbook Committee

Guidelines for ACIATE Yearbook Topic Selection

With reference to a specific topic:
1. It should make a direct contribution to the understanding and the improvement of industrial arts teacher education.
2. It should avoid duplication of the publication activities of other professional groups.
3. It should confine its content to professional education subject matter of a kind that does not infringe upon the area of textbook publication which treats a specific body of subject matter in a structured, formal way.
4. It should not be exploited as an opportunity to promote and publicize one man’s or one institution’s philosophy unless the volume includes other similar efforts that have enjoyed some degree of popularity and acceptance in the profession.
5. While it may encourage and extend what is generally accepted as good in existing theory and practice, it should also actively and constantly seek to upgrade and modernize professional action in the area of industrial arts teacher education.
6. It can raise controversial questions in an effort to get a national hearing and as a prelude to achieving something approaching a national consensus.
7. It may consider as available for discussion and criticism any ideas of individuals or organizations that have gained some degree of acceptance as a result of dissemination either through formal publication, through oral presentation, or both.
8. It can consider a variety of seemingly conflicting trends and statements emanating from a variety of sources and motives, analyze them, consolidate and thus seek out and delineate key problems to enable the profession to make a more concerted effort at finding a solution.

Approved, Yearbook Planning Committee
Previously Published Yearbooks

*1. Inventory Analysis of Industrial Arts Teacher Education Facilities, Personnel and Programs, 1952.
*3. Some Components of Current Leadership; Techniques of Selection and Guidance of Graduate Students; An Analysis of Textbook Emphases; 1954, three studies.
*6. A Sourcebook of Reading in Education for Use in Industrial Arts and Industrial Arts Teacher Education, 1957.

*Out-of-print yearbooks can be obtained in microform 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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California University of Pennsylvania
Preface

The concept of Technology Education as a natural evolution for industrial arts curricula has caused a great deal of concern in the profession during recent years. In 1980, a series of symposia initiated a debate of the issues, clarification of the philosophy, and identification of the appropriate content. During the process, a need was identified to provide resources, for educators at all levels, on implementation strategies, procedures, and examples for Technology Education. Thus, the idea for *Implementing Technology Education* was born. The proposal for this yearbook was presented to the ACIATE Yearbook Committee at the 1982 AIAA (ITEA) Conference.

Since that time, a great deal of progress has been made at local, state, and national levels that reinforced the concept of Technology Education. The national associations have re-aligned their philosophies, created long range plans, and changed their names to reflect the study of technology. Several states and local school districts have also made significant changes which include planning, curriculum updating, and name changes.

This yearbook is dedicated to those who have tried the new and braved the consequences of possible failure. But it is really written for those who see the promise of Technology Education and who desire to make a change. *Implementing Technology Education* provides clear, concise instructions, suggestions, hints, activities, and methodology for
change. As we continue to “fine tune” our curricula for industrial arts/technology education to reflect a technology-based approach, we hope this resource will help.

A rationale for change is the lead-off chapter. Change agents should use the information in the first chapter to help justify their proposals for change. The following three chapters are categorized by educational level including the elementary school, middle/junior high school, and high school. Each of these chapters focus on how to implement a technology education program and includes activities for your classroom and laboratory.

Two chapters comprise the major section of the yearbook. While both are on the undergraduate teacher education program, one focuses on the Professional Sequence and the other on the Technical Sequence. The final chapter is concerned with graduate programs in Technology Education.

We sincerely hope that the content of the yearbook will provide direction and help for curriculum developers, teachers, teacher educators, administrators, policy makers, and students of change wherever they may be.

Ronald E. Jones
John R. Wright
Acknowledgements

We would like to express our sincere thanks to the many individuals who made this project possible and provided valuable assistance in its completion.

It is always a distinct pleasure to work with professionals. Our authors are truly professionals. They provided help and suggestions, produced high quality manuscript, and most importantly, met deadlines. Working with individuals of this calibre provided us with the opportunity to deliver manuscript ahead of every deadline.

A special note of thanks is extended to two people. Deborah A. Woodley prepared all the artwork for the book with the exception of two pieces. As usual, her work was excellent, on time, and mistake free. Marianne Aamot spent many hours at the word processor putting a 330 page manuscript into usable form.

We are grateful to Bennett & McKnight, a division of Glencoe Publishing Company, for their information and assistance during the project. Finally, a special thanks is due to those who offered encouragement, enthusiasm, and support throughout the project.

R.E.J.

J.R.W.
Chapter 1

A Rationale For Technology Education

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In the spring of 1970 a group of graduate and postgraduate students at West Virginia University were presented with the question of “What title should be given to a program designed to help students comprehend their technological inheritance and technological future?” After careful deliberation, it was decided that such a program should be called Technology Education. Thus the first program in the history of the Industrial Arts profession changed its name to reflect contemporary technology. In the years following, many colleges and universities have renamed and restructured their Industrial Arts education programs to reflect a technology-based orientation. Public and private schools are beginning to follow suit.

Now, fifteen years later, the questions which prompted the action at West Virginia University still remain. Is this unusual at a time when the current buzz word is “high technology?” This introductory chapter will attempt to provide insights into the rationale, not only for the name Technology Education, but also provide a rationale for the study of technology as a discipline base. The ultimate test for any curricular structure is its potential for implementation. Therefore, this chapter will conclude with implementation strategies for those planning for change.
THE CHALLENGE

The challenge of the curriculum builder is to keep in perspective the needs of learners within the context of their environment. Frymier, Wilhour and Rasp (1973) stated that:

Man affects what is around him, and is affected in return. That point is simple and yet profound. It is so obvious that it hardly seems worth making, but it is so important that those who are environment builders — curriculum construction is the term we usually employ — must grasp its significance or lose their own sense of perspective. (p. 88)

The ultimate goal, as Teal and Reagan (1973) indicate, is to educate humans so they become autonomous individuals. That goal must also provide students with the appropriate tools so they can choose for themselves among varied alternatives. The educational system must help people make judgements based on standards that are acceptable because they are supported with evidence and reason.

Reaching our goal is another matter. As we move through the latter portion of the twentieth century, we face unprecedented technological change. There are few guidelines available to us since we have never experienced change of the magnitude that we do today. Naisbitt (1982) reported that “scientific and technical information now increases 13% per year, which means it doubles every 5.5 years” (p. 24). Naisbitt emphasizes that with the coming of the information society, we have for the first time an economy based on a key resource that is not only renewable but also self-generating. This means that the high school freshmen of 1986 will experience a quantum leap in the volume of information by the time they graduate four years later. The educational system needs a means of coping with this situation.

Industrial Arts educators are curriculum developers, like it or not. Coping with the rapid technological change is the greatest challenge that curriculum developers face. It presents interesting challenges for the discipline of Industrial Arts. To analyze why the discipline is intimately involved requires an understanding of the human’s interaction with the environment. This necessitates an understanding of a basic human concept. We call this culture.

CULTURE

Culture is the human’s unique way of adapting to the natural environment. It is the very core of human existence. Sir Edward Tay-
lor, in *Primitive Culture* (1889) advanced the first classic definition of culture. Taylor felt that the proper domain of culture was in everything human made and passed on to future generations who could add to it. A.L. Kroeber (1917) in *The Superorganic*, refuted the idea that human behavior could be reduced to a biological interpretation. Leslie White (1949) picked up on this concept. He felt that humans were organisms in symbolic interaction with one another. White defined culture as "an organization of phenomena-acts (patterns of behavior), objects (tools, things made with tools), ideas (belief, knowledge), and sentiments (attitudes, values) — that is dependent upon the use of symbols" (pp. 139-140). Culture provides us with the empirical orders with which we must deal day to day. Where strong referents exist, change causes disruption in the society. The basic order of a culture remains, but new inputs call for some change to take place. If decisions are adaptive, as opposed to maladaptive, change and adaptation is the result. Without this, organisms die or at least lose their competitive position. Today, in the information age, it is essential that the educational system continually alter its content and instructional strategies to keep pace with radical change.

A requisite for culture is the ability to symbol. Symbols facilitate our adaptation to the environment through the acquisition, storage, transmission, and use of information. The symbolic nature of culture allows it to be transmitted from person to person and generation to generation. It is cumulative and progressive in gaining control over nature. It is self-generating. Invention does not come about until culture has matured to admit it. Lenski (1974) tells us:

> In the final analysis, the most importance of symbols and symbol systems lies not in what they are but in what they have made it possible for many to become. They are the basic tools with which we think, communicate, calculate, plan, build, moralize, and speculate. Art, science, religion, philosophy, technology, politics — these are possible only for symbol users. (p. 18)

The human drama began with a biological transformation which perhaps took billions of years. The material universe slowly evolved through many stages of development each resulting in a level that was much more mature, complex, variegated, versatile, and capable of higher orders of communication and sustenance. Genetic systems facilitate adaptation to the environment. However, this process is very slow as contrasted to sociocultural change which moves very quickly. It is extremely important that we realize that it was more than biological evolution that got us to our current level of development. White (1949) summarizes this by saying "Thus we see that culture in all its aspects
— ideological, sociological and technological — serve man's inner, spiritual needs as well as his outer material needs” (p. 10).

The human was never well suited to the ecological niche. Animal life was able to adapt to the environment by altering its physical being. Humans, on the other hand, were limited in their eyesight, their ability to stand upright, their ability to grasp due to lack of the opposable thumb, and initially a smaller brain size than that of today's human. The physical ability to speak was perhaps the last biological trait gained by the human. More importantly, the human did not have history and lacked any type of inventory. In spite of this, the human had to figure out ways to survive in a hostile environment. Bronowski (1973) stated:

But nature — that is biological evolution, has not fitted man to any specific environment. On the contrary, by comparison with the grunion he has a rather crude survival kit; and yet — this is the paradox of the human condition — one that fits him in all environments. Among the multitude of animals that scamper, fly, burrow, and swim around us, man is the only one who is not locked into his environment. His imagination, his reason, his emotional subtlety and toughness make it possible for him not to accept the environment but to change it. And that series of inventions, by which man from age to age has remade his environment, is a different kind of evolution — not biological, but cultural evolution. (pp. 19-20)

As indicated earlier, culture has as its requisite the ability to symbol. The symbolic nature of culture allows it to be transmitted from person to person and generation to generation. It is cumulative and progressive and becomes the instrument whereby individuals adjust to their total setting and gain means for creative expression. The educational system is our formal means for gaining an understanding of our inherited environment and for the acquisition of knowledge for perpetuating human life. Once we process educational philosophy, we can only conclude that a curriculum theory must be derived from a study of culture. Education is one of the adaptive systems utilized by humans for survival.

**ADAPTIVE SYSTEMS**

The human adaptive systems (ideological, sociological, technological) as identified by White, have received support by many scholars, such as Fletcher (1981), Bierstedt (1974), Lenski (1970), as well as proponents of technology education programs. Although White (1959) claimed that technology is paramount among the three adaptive systems, and that the other two rely on it, this discourse will not claim a preemi-
nence or dominance for technological systems. To do so, would negate or at least lessen, the obvious inter-connectedness and interdependent nature of all systems as they work together in a human-made and natural environment (See Figure 1-1) to provide cultural diversity and continuity. (Hales & Snyder, p. 7)

Figure 1-1. The human adaptive systems work together in a human made and natural environment.

Systems are a set of objects or constructs which are interconnected in a dynamic relationship. If one element of the system is altered, it ultimately impacts all other elements. Human systems are open systems which are dynamic and tend towards growth and differentiation. Closed systems, on the other hand, tend towards disintegration and entropy. We are concerned with communication and feedback to see how a system maintains equilibrium. Therefore, to use the traditional temperature/thermostat/furnace analogy does not work when discussing human systems. This would imply that there can be no change without change in the organization itself. Closed systems stress maintenance whereas open systems stress a continual renewal process. Thus, human systems are less perfect and it is imperative that we use the term “system” with caution to avoid destroying our image of social reality. (Lenski, 1970).
Sociological Systems

Sociological systems refer to structured relationships among people. There are two building blocks in these systems: individuals working together, and the roles which they fill. The sociological systems are what hold people in a society together. They control the behavior of the component parts so that the behavior of each part helps constitute an orderly, effectively functioning whole. Without the orderliness and uniformity provided we would have chaos, therefore we would not have a “system.”

In order to maintain equilibrium, humans have institutionalized their relationships via the family, religion, government, education, and economic efforts. These provide us with structure since they bring with them a set of norms, etiquette, regulations, ethics, mores, and kinships to name a few. Such endeavors impact our efforts to foster and control technological growth. The process of coping with culture begins at birth through these institutions and continues throughout one’s life. What we learn and accept becomes universal to our inner self. As a result, rapid innovation and invention can disrupt our personal and collective lives. Institutional responses are dependent upon the inertia of the institutions themselves. If the pace of change comes too fast, we have cultural lag accompanied by stress. As a result, the word “coping” becomes more important and has serious implication for all adaptive systems.

Ideological Systems

Ideological systems are those that comprise our basic belief systems. They provide us with our perception of reality in terms of referents handed down to us via our basic institutions. They are designed to legitimatize the actions of a given society and they serve as a barometer for human behavior. Technology alters social organizations and ideology. The reverse is less intense due to tradition.

We commonly refer to value systems and societal norms when we speak of ideological systems. White (1949) reminded us that ideologies can originate in technological processes, but they are passed through social systems and are influenced by them before they find overt expression. As a result, it is possible to have societies with similar and comparable technologies but dissimilar ideologies. Humans can create and bestow any meanings or value deemed appropriate by the total group. The challenge today and in the future will be to internalize values which are compatible with the human and natural environment.

Decisions concerning technological change are based on ideological systems as handed down by our basic institutions. Although ideological systems will vary, they must have a central thread — referents
— which hold a society together. The fulcrum of this delicate balance are human needs. The evolution of humans has always been culture driven. We do not inherit culture in our genes but through education. To quarrel with technology is to quarrel with the very nature of the human.

**Technological Systems**

Our reality is, in essence, made up of three entities: humans, nature, and the means we have for articulation between human life and nature. From the time humans first roamed planet earth, they have faced serious limitations. Animals have adapted genetically, but humans have adapted through the process of invention and innovation. Survival in a hostile environment required the extension and protection of the human body. These extensions are called the "technical means." Initially they were simple contrivances, (e.g., spear, bow, and wheel). However, as humans learned to record history, to experiment, and to be future-oriented, the inventory of contrivances multiplied. This required knowledge and today knowledge is the most powerful tool in the process of invention.

Studies (Kline, 1977) reveal that the pattern of using technical means is indigenous to all cultures regardless of their level of development. Over 2,000 tribes have been studied (essentially all on earth) and the technical means consistently appear as one of the primary means of survival. Sociology originally had a strong bias towards studying social institutions. Today the collective opinion has moved to what we might call a study of sociotechnical systems, that is, a study of all three adaptive systems simultaneously.

The term "technology" has taken on many meanings throughout history and has been popularized due to its ubiquitous nature. Lauda (1980) traced the first usage of the term to the year 1615. A formal definition appeared as early as 1676 and today countless definitions render the term useless in some cases, mystical in others, all of which do little to help curriculum developers. Essentially, the term can be best understood by dividing it into two parts. These are (1) technes which refers to the principle or method employed in making things, and (2) logos which refers to the study of those principles or methods. At the risk of oversimplification we might state that technology is the study of the technical means the human has initiated and utilized for survival.

Survival relies on the meeting of certain conditions. Sociologists and anthropologists are quick to point out the need for communication, production of goods and services, the distribution and transportation of goods and services, and the need for control of technical processes as well as the control of people themselves. Writers in the discipline
of industrial arts, who advocate Technology Education, have identified with these needs and expressed them in various curriculum models (DeVore in Shepherd, 1983; Stadt, undated; Snyder and Hales, undated; Lauda & Wright, 1983). These approaches will be discussed in a subsequent section.

A TECHNOLOGICAL BASE FOR EDUCATION

The educational system of today cannot afford to provide society with individuals who live in a high technology society with a low level of technological understanding. Repeated calls for technological literacy have appeared in the past several years. The National Science Board Commission's (1982) report entitled "Today's Problems, Tomorrow's Crises" is one example of this warning. Their report states that the educational system must be able to broaden the pool of students who are prepared and highly motivated for careers in math, science, and technology. The root of the problem is really the public's perceptions and priorities for education. As a result, we are preparing a generation of Americans, many of whom lack the understanding and the skills necessary to participate fully in the technological world where they will live and work. Compounding this problem, the Commission warns us, is that very few high school teachers have formal preparation to give students an understanding of modern technology.

Two questions must be answered: (1) Is technology capable of being studied, that is, can technology be considered a discipline, and (2) Where in today's curriculum does such a program belong?

Discipline Base

Each discipline has a central thread which provides it with structure. They strive to present a complete and systematic account of a portion of the human drama. The world is ordered allowing each discipline to interpret a specific part of it. Therefore, it must have specific principles for identifying, describing and explaining certain phenomena. Different disciplines focus and interpret the same phenomena at times. Weinberg (1967) reminds us that society's problems arise from social, technical, and psychological conflicts and pressures. These problems are not generated in any single discipline, therefore their resolution cannot be found in any single discipline. Some disciplines teach us to visualize, some to conceptualize, others to utilize knowledge. The test of a discipline is in its ability to identify its knowledge and its means to gain new knowledge.
King and Brownell (1966) remind us that:

With respect to curriculum theories in general, most theories appear vulnerable on the point of providing an adequate bridge between school practice and the realm of knowledge. (p. 112) and that: With rare exception, theories for elementary and secondary school curricula, including those purported to be based on "subject matter," seem as though they are atomistic, or unsystematic, or often processes of learning from which nothing follows. They regard disciplines as if they have fully known boundaries, limits, or stopping points, or are static. They fail either to tell or to demonstrate that a "subject" is essentially a mode of inquiry about something. (p. 113)

DeVore (Spring, 1964) provided the discipline with the classic piece of work entitled "Technology: An Intellectual Discipline." In this monograph DeVore utilized the work of Shermis (1962) to justify technology as a discipline. Shermis took the position that an intellectual discipline is not a self-contained and static entity but rather a process. The 20th century is seeing disciplines emerge by first addressing themselves to significant questions and developing tools to answer them. These tools are not merely technical or mechanical, but genuinely conceptual. DeVore utilized Shermis' characteristics of a discipline to make his justification. These were:

1. A rather impressive body of time-tested works.
2. A technique suitable for dealing with their concepts.
3. A defensible claim to being an intimate link with basic human activities and aspirations.
4. A tradition that both links the present with the past and provides inspiration and sustenance for the future.
5. A considerable achievement in both eminent men and significant ideas. (p. 84)

King and Brownell provide a similar set of characteristics:

1. A discipline is a community of persons.
2. A discipline is an expression of human imagination.
3. A discipline is a domain.
4. A discipline is a tradition.
5. A discipline is a syntactical structure — a mode of inquiry.
6. A discipline is a conceptual structure — a substance.
7. A discipline is a specialized language or other system of symbols.
8. A discipline is a heritage of literature and artifacts and a network of communications.
9. A discipline is an evaluative and affective stance.
10. A discipline is an instructive community. (p. 95)

Technology has always been a primary determinant of our culture. Its history is as old as the human race and it most assuredly helps to usher us into the future. There is a body of knowledge that is uniquely qualified for inclusion in the curriculum which helps students comprehend their technical means. It may be that a technologist can understand tools and materials in a way that the nontechnologist cannot, but it does not follow that a nontechnologist cannot understand technology at all. Students need to differentiate characteristics of the technical means as they relate to problems at hand in terms of the content identified for a technology education program. At the same time they must understand, or at least be tolerant, of the input of other disciplines to the same problems.

Like science, technology pursues knowledge, but of a different kind. In science we pursue the reality that exists in the natural environment. In technology we study the realities generated by the human. Science is therefore concerned with what is and technology with what is to be. To stifle or negate the importance of study in technology education programs is to deny the student the right to comprehend one of the basic means utilized for survival in the past, present and future. No educational system can afford such naivete.

Shermis (1962), King and Brownell (1966), and Skolimowski (1966) contribute to our discussion of intellectual disciplines by referring to them as a process through which individuals utilize their talents to affect society and culture. Such a claim may seem to be vague but it does help by calling to our attention the need for students to understand the true meaning of technological progress, that is, that process which has helped the human survive. Placing parameters on such study is the key so that the discipline does indeed have structure and enough flexibility to avoid having it become a self-protecting enclave.

Skolimowski (1966) provided us with a fitting analysis of technological progress while warning us of the difficulties in making our analyses:

In the twentieth century and, particularly in our day, technology has emancipated itself into a semi-autonomous cognitive domain ... A fruitful way of reconstructing the epistemological status of technology is through grasping the ideas of technological progress. Technological progress is the pursuit of effectiveness in producing objectives of a given kind. The purely technical elements, such as the accuracy of durability of our products, are often considered in larger economic frameworks which complicate the basically tech-
nological categories. In addition, the standards of beauty and utility are becoming intrinsic ingredients of technological products, and thus makes our analysis even more difficult. (pp. 382-383)

A Curriculum Movement

It would be inappropriate to state that the educational system has not contributed to the understanding of technology. Many disciplines have made a contribution to such education. However, it is appropriate to state that no single discipline has accepted the challenge to provide students with a comprehensive understanding of technological progress. In the 1960's many efforts were undertaken in order to respond to the challenges presented by Sputnik, (e.g., The Engineering Concepts Curriculum Project.) Such efforts, and those called for today, revolve around the disciplines in science and mathematics. Compounding the problem is the fact that the term technology is used either interchangeably or in concert with science with little regard for its meaning and implications. The vast difference between science and technology has been blurred and has stifled the potential for unique curricular models. The key to scientific and technological literacy is to help those disciplines amplify each other rather than compete with one another.

Industrial Arts Responds

The subject matter area of industrial arts has been involved with the study of technical means since its conception early in this century. Although the literature is not replete with references concerning the term technology, it does present attempts to help students understand tools and materials. By implication, in many cases, one can build a good historical record for early attempts at some form of technological literacy for students.

The authors run the risk of overlooking leaders in the discipline when identifying projects dealing with technology. It is essential, however, that an attempt be made to present some of the more recent work completed. Table 1-1 presents a chronological listing of people and events which are illustrative of the contributions from the discipline. The reader should consider acquiring and reading these documents in order to become acquainted with the lineage of technology education programs.
TABLE 1-1
CHRONOLOGICAL LIST OF SELECTED LEADERS AND THEIR CONTRIBUTIONS TO TECHNOLOGY EDUCATION

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Contribution</th>
</tr>
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<tbody>
<tr>
<td>William Warner</td>
<td>1928</td>
<td>Formed Epsilon Pi Tau</td>
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<tr>
<td>William Warner</td>
<td>1947</td>
<td>A Curriculum to Reflect Technology</td>
</tr>
<tr>
<td>Delmar Olsen</td>
<td>1957</td>
<td>Technology and Industrial Arts</td>
</tr>
<tr>
<td>Paul DeVore</td>
<td>1964</td>
<td>Monograph — Technology and Culture</td>
</tr>
<tr>
<td>Paul DeVore</td>
<td>1967</td>
<td>I.A. Undergraduate Program Development Conference</td>
</tr>
<tr>
<td>Ron Stadt and Larry Kenneke</td>
<td>1970</td>
<td>Monograph — Teacher Competencies for the Cybernated Age</td>
</tr>
<tr>
<td>Donald Lauda</td>
<td>1970</td>
<td>I.A. Teacher Education Fellowship Program in the Technologies</td>
</tr>
<tr>
<td>Julius Paster</td>
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<tr>
<td>Paul DeVore</td>
<td>1972</td>
<td>Education in a Technological Society</td>
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<td>David McCrory</td>
<td>1973-1985</td>
<td>Technology Education: Project Open/Field Testing</td>
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<td>Ronald Jones</td>
<td>1980</td>
<td>Technology Education Symposium Proceedings</td>
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<td>John Wright</td>
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<td>R.E. Gebhart</td>
<td>1980</td>
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<td>R. Peter</td>
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<td>William Dugger</td>
<td>1980</td>
<td>Standards for I.A. Education Programs Project</td>
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<td>James Hales</td>
<td>1981</td>
<td>Jackson’s Mill Industrial Arts Curriculum Project</td>
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<td>James Snyder</td>
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<td>New York State</td>
<td>1981-Present</td>
<td>Occupational and Practical Arts Futuring Project</td>
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<td>Education Department</td>
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<thead>
<tr>
<th>Name</th>
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<th>Contribution</th>
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<tr>
<td>James Bensen</td>
<td>1981</td>
<td>Technology Education Symposium II Proceedings</td>
</tr>
<tr>
<td>Lee Smalley</td>
<td>1981</td>
<td>Technology Education Symposium III Proceedings</td>
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<tr>
<td>Thomas Wright</td>
<td>1981</td>
<td>Technology Education Symposium IV Proceedings</td>
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<tr>
<td>Wayne Andrews</td>
<td>1982</td>
<td>Industry and Technology Education Project</td>
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<td>Technical Foundation of America: Tom Wright and</td>
<td>1982</td>
<td>Technology Education Symposium V Proceedings</td>
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<tr>
<td>Len Sterry, Co-Directors</td>
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<tr>
<td>Don Shepherd</td>
<td>1983</td>
<td>Thresholds in Education: Technology Education</td>
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<td>Donald Lauda and John Wright</td>
<td>1983</td>
<td>Eastern’s Technology Education Plan</td>
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<td>Keith Blankenbaker</td>
<td>1983</td>
<td>Technology Education Symposium V Proceedings</td>
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<td>American Industrial Arts Association</td>
<td>1984</td>
<td>Professional Improvement Plan 1983-86</td>
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<td>Illinois State Board of Education: Ronald</td>
<td>1984</td>
<td>The Illinois Plan</td>
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<td>Jones, Franzie Loepp, and Conard White</td>
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<td>Jule Dee Scarborough</td>
<td>1984</td>
<td>Technology Education Symposium VI Proceedings</td>
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<td>Virginia Polytechnic Institute and State</td>
<td>1985</td>
<td>Standards for Technology Education Project</td>
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<td>University</td>
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<td>American Industrial Arts Association</td>
<td>1985</td>
<td>Technology Education: A Perspective on Implementation</td>
</tr>
<tr>
<td>Nevin Andre and John Lucy</td>
<td>1985</td>
<td>Technology Education Symposium VII Proceedings</td>
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</table>
Epsilon Pi Tau is listed as a major input into the lineage because its precepts portray exceedingly well the interdependence of the technical means, research and social concern. This triadic nature that lies at the base of this honorary fraternity is an excellent expression of the call for a blending of the adaptive systems. Subsequent efforts within the profession have been extensive. Perhaps the most prolific writer of all has been Paul DeVore. His original work at State University College at Oswego (New York) and his later work at West Virginia University cannot go unnoticed. His consistent call for an understanding of technology within the discipline has laid the groundwork for programs at all levels.

The first undergraduate program devoted to Technology Education (Lauda & Wright, 1983) was developed at Eastern Illinois University. A spin-off of this program was the Technology Education Symposia conceived and initiated by Drs. Ronald E. Jones and John R. Wright (1980). This effort has resulted in an annual symposia devoted to Technology Education. Such efforts have also been reflected in programs and publications of the International Technology Education Association (formerly the American Industrial Arts Association) and the American Council on Industrial Arts Teacher Education.

At the present time one can find the call for technology education programs in a variety of sources. The name Technology Education is often used by a variety of groups (e.g., NSF). It would be premature to assume that any one discipline has assumed the total leadership for technology education. Most assuredly, the discipline of industrial arts has begun its efforts towards this goal.

**Why Industrial Arts?**

Of all the disciplines in the educational system, it has been industrial arts that has had a rich heritage in helping students understand their technical heritage, albeit these have been geared to the past and have been represented out of context. For three-quarters of a century, industrial arts has been working in areas which represent basic activities used for survival, e.g., constructing, communicating. The discipline has done an excellent job throughout the years and has made a phenomenal contribution to the growth of millions of students.

Three problems have existed, and still exist in most cases, with traditional industrial arts programs. These are as follows:

1. The programs have been materials/project oriented, making them involved with technical processes without conscious concern for the sociocultural context in which they exist. [Wright (1980) makes a good case for a distinction between the terms technical and technological.]
2. Industrial arts has not been involved with all of the technical means in most programs. Absent from most programs are content and instructional strategies that deal with transportation. The Standards Report (Dugger, 1980) reveals that most programs are still based on the teaching of woodworking, metalworking, and drafting.

3. Programs have not kept pace with the changing technology. Updating laboratories to reflect contemporary technology is cost prohibitive and alternatives to this problem have not been a high priority for many teachers.

The answer to the question, “Why Industrial Arts?” lies in its history, and more importantly, its potential for amplifying content concerning the technical means in its sociocultural context. To learn about the technical means requires a laboratory setting so that students can become intimately involved with tools, materials, processes, information, and new ways of thinking. Such laboratories are already in existence in the public schools. Granted, they need to be modified, but they do exist. No other discipline has attempted to teach about our technical means except vocational education. However, the technology education programs being advocated in this yearbook fit into the general education program and as a result should be called Technology Education.

**ANTICIPATED OUTCOMES**

All educational systems must first decide what content is essential for students and then select the physical setting in which it must be undertaken. What has been suggested in the first half of this chapter is the need for the discipline of industrial arts, which has an established heritage, to change its philosophical base. Change for change’s sake is unacceptable. Change to improve industrial arts by bringing it in line with contemporary and future society is another matter.

Industrial arts is part of general education and like other disciplines in general education, runs the risk of being too broad, superficial, and expendable when budgets are tight. It is essential that the potential inherent in Technology Education programs be conveyed with precision and academic integrity. Most importantly, the discipline must embrace desired habits of mind and action for future use by every student. The educational system is an initiation into civilization and must contribute to the students’ understanding of it as well as to the student’s participation in it.
What Does the Student Gain?

The student gains a comprehension of the human endeavor we call technological process. Civilization is more than buildings, cities, devices, and tools. It embraces emotions, beliefs, ideas, and methods of thinking, all of which are involved in invention and innovation. Today's information age is demanding and calls for individuals who can function with their technical means and within the institutions established for developing, utilizing, and controlling those means. Technology Education can provide content and instructional strategies within a laboratory setting which introduces students to technological concepts.

The student gains a content base which will amplify work in the other disciplines. This is inevitable since the use of technical means is basic to human existence. So long as the discipline merges the technological, ideological and sociological systems together, interdisciplinary benefits are inevitable. This does not negate many of the traditional benefits of industrial arts (i.e., appreciation of materials, consumer knowledge, good safety habits and development of basic skills). Rather, it amplifies them and helps the student cope with changing technology.

In essence, the student has a headstart on gaining technological literacy. Today no discipline is structured to provide a broad understanding of technology. The appearance of such a program is long overdue. The discipline of industrial arts has taken great strides to accomplish this effort. To deny students access to such a program is to deny them an understanding of their part, present, and future in a technological world.

HOW SHOULD TECHNOLOGY-BASED EDUCATION BE IMPLEMENTED?

Effective technology education programs don’t just happen; they result from a complex set of curriculum development and implementation procedures. The procedures are complex because a number of variables must be considered (Table 1-2). Intended learnings (knowledge, skills, attitudes) must be related to the teacher’s skills, the learner’s capabilities, and the constraints of school schedules and facilities.
TABLE 1-2

CURRICULUM IMPLEMENTATION VARIABLES

<table>
<thead>
<tr>
<th>Subject Matter</th>
<th>Teaching Style</th>
<th>Learning Style</th>
<th>School Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of subject</td>
<td>Knowledge of teacher’s style</td>
<td>Knowledge of learner’s style</td>
<td>Knowledge of school organization</td>
</tr>
<tr>
<td>Methods relating to subject</td>
<td>Methods relating to teacher’s style</td>
<td>Methods relating to learner’s style</td>
<td>Methods of school organization</td>
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<tr>
<td>Values relating to subject</td>
<td>Values relating to teacher’s style</td>
<td>Values relating to learner’s style</td>
<td>Values relating to school organization</td>
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There are five major steps in implementing a technology education program: (a) develop a curriculum design, (b) develop a curriculum plan based on the design, (c) develop instructional materials to support the curriculum, (d) provide inservice training for teachers and administrators, and (e) field-test, evaluate, and revise the program. Each of these phases will be discussed below.

DEVELOPING A CURRICULUM DESIGN

Effective curriculum implementation begins with a sound curriculum design. The curriculum design serves as a guide for decision making, provides a rendering of the curriculum, and defines an organizational structure of people and procedures for the task of developing and implementing curriculum plans. Specifically, a curriculum design sets forth a rationale for developing a particular curriculum; identifies the nature of the curriculum decisions to be made; identifies and justifies the criteria for selecting and organizing the curriculum elements; and provides an overall structure for the curriculum to be developed.

Ideally, a curriculum design should be developed before the curriculum plan. Although curriculum designs are not always explicit, curriculum planners normally work from a design-like set of assumptions and value positions as they develop new curricula. If the new curriculum program being implemented has no explicit design statement, one
should be developed. This is especially important if the change is to involve a number of school districts or an entire state. If financial or time constraints make it impossible to develop a new curriculum design, an existing design should be adopted. The Jackson’s Mill curriculum model (Snyder & Hales, 1981), for example, could serve this purpose. (Note: in the remainder of this chapter, the Jackson’s Mill document will be referred to frequently because it is currently one of the best examples of a comprehensive curriculum design for Technology Education programs.)

Curriculum Rationale

A curriculum rationale sets forth the basic assumptions upon which the curriculum is grounded. Previously, we described a general rationale for including Technology Education in the school program. Although the general rationale helps identify reasons for program change (i.e., from a crafts base to a technology base), a more detailed rationale is needed for curriculum development and implementation. A curriculum rationale presents:

- assumptions about students, the needs of society, and the nature of the subject matter;
- states the purpose of the curriculum;
- identifies data sources;
- provides an outline of the subject matter to be taught.

Curriculum Assumptions. Assumptions about students are important if curriculum planners and implementers are to know who are the intended learners and what implications there are for the curriculum structure. For example, if the new technology education program is to serve all students in the target school system regardless of size, shape, color, or level of motivation, then general student characteristics should be identified and implications drawn for the curriculum plan. Snyder and Hales (1981) describe general learner characteristics in relation to early childhood, middle childhood, adolescence, and adulthood (pp. 40-41). If a curriculum plan is to be used with a particular group of students, the design should specify student characteristics in as much detail as possible. For example, if students with special needs are to be served by the program, there may be important implications for the types of tools, machines, work surfaces, and other components required for implementation.

The curriculum rationale must also identify assumptions about needs and wants of the larger society. Technology-based curriculum designs usually assume that society, at least in the Western World, is uniquely technological. The Jackson’s Mill design (IBID) notes that the
increasing complexity of technical systems has brought with it some
difficult personal and social choices. By implication, the design assumes
that students should acquire "an understanding of the behavior of these
systems and the relation of these systems to human beings, their social
purpose, and the environment" (p. 4).

Significant assumptions about subject matter should also be iden­
tified in the curriculum rationale. In the Jackson's Mill design (IBID),
three domains of formal knowledge (sciences, humanities, and technol­
gies) are identified. The technologies are further defined as the tools,
resources, techniques, and systems used by humans to modify their
natural environment (pp. 5-6). It is unlikely that any two technology edu­
cation program designs will be similar if they are predicated on different
assumptions about the nature of technology. For example, if a given
curriculum design defines technology as technique, the resulting cur­
riculum will focus mainly on the teaching of tool and machine process
skills, e.g., most traditional arts and crafts programs. A contrasting
design which defines technology as a body of knowledge, will result
in a curriculum which emphasizes conceptual understanding (DeVore,

Technology education content should be clearly presented in the
curriculum design with implications for curriculum structure. Defini­
tions of topics, concepts, principles, generalizations, and the like, should
be defined in a hierarchy of relationships. The Jackson's Mill design
(Snyder & Hales, 1981) highlights the systems model — input, process,
output — as a means of selecting and studying curriculum content in
the "universal technical systems" of construction, manufacturing, trans­
portation, and communication (p. 16).

Purpose of the Curriculum. The decisions to be made in each step
of the curriculum development and implementation process require that
the curriculum's purpose be clearly stated. One of the perennial issues
in technology education curriculum development revolves around the
question of whether a new program should be designed toward prepar­
ing selected students for specific vocations or whether it should pro­
vide general technological literacy for all. Some of the more recent
state-wide curriculum projects proclaim to do both. Whichever empha­
sis is chosen it should be clearly stated in the design. Consequently,
all other components of the design, and the resulting curriculum, should
be developed to achieve the design's stated purpose. To do otherwise
could hurt the credibility of the new program by confusing teachers
and supervisors who are expected to implement the new program.

Curriculum Data Sources. By citing data sources, a curriculum
design makes some choices from the myriad of possibilities and pro­
vides parameters for subsequent curriculum development and imple­
mentation decisions. These data sources should be consistent with the
design's stated purpose and assumptions about the nature of students, society, and subject matter. It would be inconsistent for a technology education curriculum design to claim contemporary technology as its primary content focus and then cite arts and crafts information as its major data source.

Curriculum Content. Following the specification of data sources, the curriculum design should identify the types of content to be learned by students interacting with the curriculum. Content should be derived from the suggested data sources. Traditional industrial arts curriculum designs use content primarily concerned with industrial materials (woods, metals), processes (drafting, graphic arts), or physical phenomena (electricity, energy/power). As an alternative, McCrory (1980) has suggested a technology education curriculum model which identifies six elements (humans, energy, tools, materials, information, processes) to be studied in the contexts of production, transportation and commu-

![Diagram of content matrix for Technology Education curriculum.](image)
A number of programs based on variations of this model have been implemented in West Virginia schools (Andrews and Kleine, 1977).

**Decision-Making Criteria**

Along with clearly stated assumptions, purposes, data sources, and subject outline, a curriculum design also should identify and justify criteria to be used in making further curriculum decisions. Decision-making criteria cut across many other categories in the curriculum design, and should provide guidance regarding the curriculum's orientation, relevancy, balance, and organizing themes.

**Curriculum Orientation.** Orientation, in a curriculum context, refers to the intended focus of the educational program. In essence, the orientation component of a curriculum design is much like an architect’s rendering in that it offers an overview of the object to be constructed. In a curriculum design, these criteria help clarify if the curriculum plan is to be future-oriented, or problem-oriented.

Some members of our profession believe that a curriculum orientation toward a conceptual study of technology inherently neglects hands-on learning activities. This myth should be put to rest once and for all. All technology education programs must be activity-oriented to some degree. The real issue is one of focus; that is, whether content or learning activities should be the major curriculum determinant. One of the major decisions to be made about technology education programs, then, is what types of learning activities are to be included in the program.

A curriculum which focuses on concepts will still require appropriate hands-on activities to facilitate conceptual learning. By the same token, having an activity-centered curriculum does not preclude the need for students to read, study, and engage in discussions about the fundamental concepts and principles of technology and how technology affects humans. Jackson's Mill (Snyder & Hales, 1981) is oriented toward a combination of technical and social aspects. According to its designers, “the model places emphasis on subject matter within human technological/sociological endeavors while providing an integration with the natural environment within a time dimension” (p. 18). This implies a problem solving orientation based on socially relevant problems of a technical nature (p. 42).

**Curriculum Relevancy.** Many curriculum designs either implicitly or explicitly call for the selection of “relevant” learning activities or “activities with meaning.” However, few designs clarify what is meant by these terms. In such cases, curriculum developers and implementers are left on their own to decide what content and activities are rele-
A Rationale for Technology Education

vant; and their choices may not always be what the developers had in mind. An effective curriculum design should provide examples and criteria for choosing among the broad range of teaching and learning activities.

The Jackson's Mill design (Snyder & Hales, 1981) speaks to the relevancy issue by suggesting that students should "develop creative solutions to present and future societal problems using technical means" (p. 42). One implication of this statement is that some student activities should focus on local problems such as inadequate sewerage systems, decaying housing, or poor public transportation. Local relevancy can be an effective criterion, as it was in one technology education program developed for a rural West Virginia middle school (Scanlin & DeLuca, 1980). That program emphasized the study of local farming and lumbering technologies because they provided a relevant link with prevailing student interest and community needs.

Curriculum Balance. Balance is identified in the design by making evident the domains of learning (cognitive, affective, and psychomotor), content (concepts, skills, values), and the organizers (themes, principles, generalizations). For example, if it is intended that classroom study time (cognitive) should approximately equal laboratory work time (psychomotor), then it should be so stated in the curriculum design. If balance is not clearly specified in the design, the curriculum as implemented may vary considerably from what was intended.

Organizing Themes. A curriculum design which specifies technology as the content focus still requires an organizing theme. The Jackson's Mill design (Snyder & Hales, 1981) employs the systems model as its major organizer. Other designs use appropriate technology, community technology, high technology, research and development, and research and experimentation as central themes.

Criteria for Selecting and Organizing Curriculum Components

The design must specify the nature of the curriculum decisions to be made, who is to be involved in making which decisions, and what decision making procedures will be used. Curriculum components should be selected by following these steps: (a) analyze subject matter, (b) break content into its elements, (c) state objectives, (d) specify exemplary learning activities, and (e) identify evaluation procedures.

Objectives can be stated as learner outcomes, student competencies, or student behaviors. Likewise, there are several ways to indicate the nature of learning activities and evaluation procedures. The design statement should specify what format and style is desired for organizing the components of a curriculum plan. The Jackson's Mill design (Snyder & Hales, 1981) suggests a "learning system" format to
be used for developing instructional plans (p. 43). The learning system format identifies concepts, essential competencies, learner outcomes, teaching strategies, media/resources, and evaluation techniques as the major components of an instructional plan.

Among the most neglected design criteria are those related to evaluation. Such criteria should address the perennial question of how to determine what the students have learned and how well they have learned it. For example, a technology education curriculum design should identify how teachers are to determine if students understand the significant technical developments in a post-industrial society and how they differ from those in an industrial-based society. Is a multiple choice test adequate to assess a student’s level of technological literacy? How does one evaluate problem solving skills, if that is the curriculum goal? What kinds of problem solving skills give evidence of what types of learning? The curriculum design should address questions such as these by providing procedures for evaluation and some guidelines for interpreting the results.

DEVELOPING A CURRICULUM PLAN

Although the curriculum design presents an overview of the program to be implemented, it alone cannot provide the detail needed by teachers and supervisors who will implement the program. A curriculum plan must be developed to bridge the gap between general guidelines provided by the curriculum design and the specific needs of teachers at the implementation sites.

What are the characteristics of an ideal curriculum plan? Curriculum scholar John Goodlad (1966) has said that an effective curriculum plan is more than “merely an arrangement of topics in an ascending order of difficulty believed to be inherent in the subject” (p. 91). Goodlad and other curriculum theorists agree that what actually happens in the classrooms and laboratories should be the end product of a series of decisions made deliberately and consciously rather than by default.

A curriculum is a set of plans that identify and justify an arrangement of people, content, materials, time, space, and activities directed toward attaining desired educational goals and conditions. Because only a limited amount of the universe of possible curriculum elements (content, purposes, materials, etc.) can be included in any one curriculum, difficult choices must be made. A curriculum is a particular statement of educational values. It identifies who is intended to learn what, how, when, and why; and is usually justified in terms of claims about the needs of society, what is worth learning and/or what constitutes an educated human being.
DEVELOPING INSTRUCTIONAL MATERIALS

In many curriculum change projects, especially those involving technology education programs, the task of selecting, developing or modifying instructional materials is a major undertaking. There are several factors to be considered when developing instructional materials: the nature of the students being served; the objectives, content, and organizers; and the cognitive, affective, and psychomotor processes of the curriculum. Instructional materials may be of a print or non-print nature, student or teacher controlled, linear, or multidimensional. They may take the form of textbooks, computer programs, simulations, films, or three-dimensional models. For a technology education program, traditional craft-oriented industrial arts textbooks and other print materials may not be useful. Recently, publishers have begun to produce some materials appropriate for updated programs. However, curriculum developers should examine these new materials carefully in order to select those which effectively reinforce the learnings intended by the specific program design.

Most implementers of technology education programs find it necessary to develop additional curriculum materials. Wherever possible, teachers and supervisors should be involved in locating, selecting, and developing new instructional units. In some cases, especially regarding recent technologies, current technical journals may be a good source of information. Information from technical sources should be translated into instructional materials understandable by students. The Resources In Technology inserts published in the 1982-83 issues of *Man/Society/Technology* and in the 1983-84 issues of *The Technology Teacher* may serve as one example of how this may be done. For a description of formats and procedures for developing technology education resource materials, see McCrory and Maughan (1983). Some technology education curriculum development projects, such as the New York Futuring Project, have included curriculum materials development as an integral part of the inservice training activities (The Plan, 1981). As teachers engage in purposeful development of curriculum materials, they tend to become more comfortable with the new curriculum plan and discover effective means to implement it.

PROVIDING INSERVICE TRAINING

The importance of inservice training for curriculum implementation is identified in the Curriculum Management Handbook (1979) produced for the Commonwealth of Puerto Rico. The handbook states: "The
best of plans are all for naught if those who must translate them into practice do not understand them, are not committed to them, or do not have the skills to enact them" (p. 8-1). In large-scale state or regional curriculum projects, inservice training should be provided for teachers, administrators, and supervisors before curriculum implementation is attempted.

Inservice training for curriculum implementation must enable the instructional staff to comprehend the rationale, purposes, basic strategies, content, and evaluation procedures of the curriculum. Teachers must also master the instructional strategies, their pattern, direction, and theoretical undergirdings, and learn to appropriately use the instructional materials that support the strategies. Perhaps most importantly, all persons involved in the curriculum implementation process must become committed to the essence of the curriculum and believe in its integrity, purpose, and possibilities for enhancing student learning.

Those in charge of curriculum implementation should understand that curriculum change projects often exist at several different levels (Figure 1-2). As a general rule, the more comprehensive the level, the more difficult it is to achieve effective implementation because of the increasing number of persons involved. State-wide implementation projects, such as those in Illinois and New York, involved hundreds of educators, administrators, and advisory persons. In large-scale implementation projects such as these, it is nearly impossible to directly involve in the curriculum development process all of the local teachers, supervisors, or administrators who will be affected by the new curriculum. Thus, local personnel require effective inservice training to become familiar with the new curriculum's structure and to learn new skills and information necessary for implementation.

![Figure 1-3. Levels of curriculum implementation.](image)
Historically, most large curriculum implementation projects have used a top-down approach, with curriculum guides being developed by a handful of selected persons. If judged on how effectively the new curricula were implemented at the local levels, many of these projects could be considered as failures. Some projects suffered primarily because they failed to carry out effective inservice training and curriculum material development.

Ordinarily, implementation can be achieved more quickly at local or district levels, in part because fewer persons are involved. In some local projects, specific schools are usually selected as pilot implementation sites. Individual teachers and supervisors at these sites are then directly engaged in developing and implementing a new program. In such cases, implementation is much more likely to be effective because the implementers are already committed to the new program.

The individual school building presents the most promising potential for quick implementation of a new curriculum. At this level, an individual teacher or group of teachers, with support from administrators, can have an immediate impact on educational programs. This grassroots implementation model has been used in several technology education curriculum development projects in West Virginia (Project Open Annual Reports, 1972-1982).

### FIELD TESTING, EVALUATING, AND REVISING

Field testing begins with selection of specific school sites for implementation of the new curriculum. Ideally, field test sites are chosen on the basis of need, but each school’s capacity for change also must be considered. Once need has been determined, the interest demonstrated by teachers and administrators is perhaps the most important single factor in site selection. Other factors, such as configuration of the facility, scheduling, and so on, can usually be overcome if decision-makers possess sufficient motivation for change.

Sometimes, personnel at the field testing sites are given special incentives, such as released time or stipends, but unless similar incentives can be provided in all of the target schools, teachers not in the field sites may feel slighted. Another potential problem is related to the expectations of those who will be involved in the field tests. Sometimes the prospect of implementing a new curriculum raises expectations far beyond what the new program can deliver. Personnel at all levels must realize that the major goal of field testing is to try out the program and to evaluate its effectiveness, not to overcome all of the school’s inadequacies in one fell swoop. Those in charge of curriculum change projects should be prepared for surprises during the first months
of field testing. Unexpected weaknesses in the curriculum may appear, or additional instructional materials and staff may be needed. Thoughtful curriculum evaluation is needed if shortcomings such as these are to be recognized and tested early.

Curriculum evaluation is the study of curriculum processes and products in order to assess their quality and effects. During field testing, curriculum evaluation provides data about the apparent effectiveness of each of the previous stages of the curriculum development. It may include the analysis of how a curriculum is being implemented, what students are learning, and how well the instructional materials are functioning. Although quantitative data, e.g., test results of student learning, are certainly important, qualitative information gained from teachers is also valuable.

Two concepts are central to the evaluation process. In essence they represent diverse perspectives on the perennial problem of educational measurement: quantitative methods versus qualitative methods. The quantitative perspective is based on the assumption that numerical measures hold educational meaning. This perspective presumes that we can infer from specific measures such as test results the educational quality of a textbook, instructional unit, or teaching strategy. The qualitative approach obtains data from the total educational activity over time in an attempt to view the whole as opposed to specific parts. Data used in the qualitative approach includes analysis and interpretation of teachers, supervisors, and other observers (for further discussion of this distinction see Eisner, 1979). Because technology education programs incorporate many kinds of learning activities, both approaches to curriculum evaluation are important.

Revision of a new technology education curriculum is an ongoing, long-term process. Curriculum revision often requires that many of the curriculum steps described above be revisited. Field test and evaluation results may require adjustment of curriculum objectives, teaching strategies, student activities, and learning materials. One common problem experienced on curriculum implementation projects is that inservice training and other staff development activities rarely satisfy all of the needs of teachers who are involved in implementation. If the new program is much different from the old, teachers will need new information and skills. Administrators, students, and parents will want assurances that the new program is superior, and that it is working (i.e., achieving its goals).

One of the most successful ways to deal with these concerns is to involve representatives of these groups, at various levels, in a program of continuing assessment and revision of the new curriculum. Teachers successful in implementation at the field test sites, for example, should serve as trainers for teachers in successive implementa-
tion sites. Special workshops and training sessions should be arranged to show others how the curriculum functions. It is usually more effective to provide such seminar sessions at various sites in the target region rather than to invite potential adopters to visit "model" implementation centers.

A CALL TO ACTION

As each day goes by, the public becomes more aware of technology and its impact on individuals and society. Studies of schooling call for improved education in math, science, and technology. The time is right for curriculum improvement efforts. The best place to implement a new program is wherever you are now, even if you are the only one within shouting distance who wants to change the existing curriculum. Don't be discouraged if your colleagues voice dozens of reasons why changing to a technology education curriculum isn't necessary. Explain your rationale, state your intentions, but don't be dissuaded by their pessimism. If you are ready to develop and implement a new technology education curriculum, we offer these suggestions:

1. Evaluate your present situation. Ask yourself what your program could be doing for all youngsters, including the academically talented as well as those who seem less capable. Consider how your program and facilities could be used to better advantage in teaching youngsters the concepts, skills, and attitudes necessary for coping with a technological future.

2. Get help from your state industrial arts specialist and officers of your state affiliate of the International Technology Education Association. Persuade the decision-makers in your state and region to include technology-oriented clinics and workshop sessions on their agendas.

3. Ask for outside support. Many schools that are making the most progress toward change have enlisted outside assistance. National leaders can provide advice, as can local or regional teachers and supervisors. Once you inquire, you might be surprised at how much is already going on at other locations, and how willing others will be to share their experience with you.

4. Attend conferences and workshops sponsored by professional organizations. The annual conference of the International Technology Education Association (formerly the American Industrial Arts Association), as well as its sponsored mini-conferences on special topics, are excellent places to get
started. Conferences sponsored by trade and technical associations are also useful for gaining new information about contemporary technology.

5. Read about the suggestions and experiences of others as reported in professional publications. Many of the references cited in this chapter provide excellent sources on information. For more background on technology education we especially recommend reading recent issues of Man/Society/Technology, The Technology Teacher, The Journal of Epsilon Pi Tau, and proceedings of the Technology Symposia. (Refer to Table 1-1) The International Technology Education Association has a number of publications to guide curriculum implementation. These sources include helpful articles written by people who are already involved in the change process; their experience can be of great value.

6. Use the "Resources In Technology" tear-out sections in Man/Society/Technology and The Technology Teacher. They may be duplicated freely, and by using them, your students can get started toward technology studies while you develop your own.

7. Take key administrators to a national or regional Technology Education conference. Show them what others around the country are doing. Let them talk with other teachers and administrators who have begun to change toward a technology education curriculum. Keep the pressure on by providing them with reprints of selected articles written by others who are changing their programs.

8. Experiment! Be bold! Try some new ideas of your own along with those of others. Begin with the point of least resistance. If you have only one class which appears to be ready for change, begin there. As you gain experience, change each of the other classes in order. Remember, before you go too far you should have an adequate curriculum design and curriculum plan to guide your efforts toward purposeful learning.

9. Call on your nearest college or university industrial arts/technology education teacher education program, the people there will be pleased to help, but you may have to initiate the contact. If you want graduate credit, ask about arranging a supervised independent study project in connection with your curriculum change effort.

10. If you are an administrator, familiarize yourself with your existing industrial arts program. Identify which teachers are attempting to move toward Technology Education, then support them in every way you can. Arrange for your instructors
to visit exemplary schools to observe, on a first-hand basis, what technology education programs can do for youngsters. Also, invite teachers from successful technology education programs to conduct inservice workshops for your staff.

SUMMARY

It was our goal in this chapter to call attention to what we believe are compelling reasons for changing outdated industrial arts programs based on agricultural and industrial era of the past. We encourage the reader to develop and implement new technology education programs designed to prepare youngsters for active roles in the future. We suggested that a well-developed curriculum design and curriculum plan are necessary antecedents if new programs are to succeed. We also provided some guidelines for planning and suggestions for implementing change.

Within the past few years there have been many promising developments in the industrial arts/technology field. Our profession has always been proud of its important role in the education of youngsters. We are now in a unique position to make a contribution even more significant than in the past. Let us make the most of the opportunity.

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The elementary school level is where the development of an essential understanding of technology should begin. Technology constitutes a universal element within all cultures and provides an important requisite for cultural survival. Sociologists Gerhard and Jean Lenski indicate that technology is “... the most powerful single factor influencing the life of that (i.e. any) society” (1978, p. 36). Because of the important relationship which exists between culture and technology, the elementary school that prepares students to understand and live successfully within their culture must include technology-based content.

Elementary school children encounter technology every day and are aware of the tools, products, and manufactured environment that exists in their homes and communities. However, these students may be unfamiliar with the knowledge of:

- how the food, clothing, shelter, other goods, and services that sustain life are produced
- how the transportation and communication needs of society are met through technology
- proper safety practices related to using the products of technology.

It has been observed that “Life depends upon a technology that most people do not understand” (DeVore, 1980, p. 215). The aim of the elementary school Technology Education program is to develop a first-hand understanding of the technology that supports daily life. This understanding is developed through tracing the evolution of technology, establishing a conceptual base to support and facilitate future learning about technology, and providing problem solving activities that allow students to apply knowledge to solve practical, technology-based problems.

The beginnings of a successful elementary school Technology Education program originate with the recognition that technology is an
essential element of all cultures and the study of technology is valuable for elementary age children. This chapter includes the process of implementing technology education — establishing program characteristics, developing the group climate for success, following the curriculum development process, and identifying and implementing technology education content through interdisciplinary units which complement existing elementary school curriculum.

**ESTABLISHING A BASE FOR PROGRAM IMPLEMENTATION**

Successful implementation of a technology education program is based in part upon initial acceptance by the local elementary school administration and teachers. The program must contribute to and enhance the goals and objectives of the local school. The program must blend the philosophies of the elementary school and technology education to establish a mutual foundation for program implementation. Table 2-1 provides a representative listing of program characteristics designed to complement and contribute to an existing elementary school curriculum.

**Advisory Group/Project Team Responsibilities**

It is suggested that the primary responsibility for program implementation be shared between two groups: an advisory group and a project implementation team. An advisory group containing representation from the community, school system administration, local school administration, teachers, and students can provide direction, support, and feedback concerning the progress of program implementation. It is important for the long term acceptance of a program to solicit input and obtain the involvement of people who have an interest in education at the elementary school level. The advisory group is in position to provide the support required by teachers to implement a program. The following list includes the kind of support which helps to encourage program development:

- Recognition for the teachers who participate.
- Planning time for project team members.
- Professional resources.
- Books to support student activities.
- Travel to visit exemplary programs.
- Material/tool resources to support student activities.
- Opportunities to attend and present project results at professional meetings.
TABLE 2-1
CHARACTERISTICS OF THE ELEMENTARY SCHOOL TECHNOLOGY EDUCATION PROGRAM

1. Relates in a functional way information taught in all areas.
2. Utilizes the children's natural interests in activity, and in manipulating materials and devices as a means for expressing themselves.
3. Ties the curriculum together — provides a unifying core for the curriculum.
4. Proceeds from specific/concrete to general/abstract activities.
5. Contributes to the development of potential and abilities present within the elementary grade students.
6. Reflects the needs and interests of the students. Develops basic competencies for living in a technological environment.
7. Integrates, unifies, and reinforces existing curricular concepts through the technological component of our culture.
8. Can be implemented through existing elementary classroom teachers or a specialist.
9. Applications oriented curriculum with specific learning experience lesson plans developed to compliment the following areas:
   - Social Studies
   - Science
   - Math
   - English—Reading, Spelling
   - Music
   - Physical Education
   - Arts
   - Learning Disabilities
   - Multiple Handicapped
   - Interdisciplinary Studies—Team Teaching
10. Has particular value in the integration of community resources into the school environment.
12. Problem oriented learning motivates students to pursue learning independently.

The second group constitutes the project implementation team. It is composed of local elementary school teachers and resource people familiar with the study of technology. The project team should have the direct responsibility for program implementation. The resource persons provide technical expertise, advise teachers on the scope and sequence of technology education content, and serve as a liaison to the advisory group. The local elementary teachers provide important knowledge about the appropriateness of technology education content, individual students, the school and community environment.
It is important that positive relationships exist among the project team members and between the advisory and project implementation groups. This positive relationship provides direct support for local teachers and encourages the input required to develop and sustain a meaningful program. As success is achieved the project team can be expanded from an established base to include other teachers willing to contribute to program development.

**Personal Characteristics/Group Climate**

The personal characteristics of individual group members contribute much to the development of a constructive working relationship. Enthusiastic, forward looking, possibility-oriented thinkers with a positive mental attitude (PMA) (Hill & Stone, 1960) are the people best suited for contributing to the establishment of an effective technology education elementary school program.

The utilization of a group-centered process for decision making is critical for gaining the support and commitment required to implement and sustain a program. Groups which are able to develop a climate of mental trust, authentic communications, and genuine respect for individual differences (McGregor, 1967) can establish the requisite base for making decisions, managing conflict, and developing commitment (Bennis, Beene, & Chin, 1969). Commitment is an essential characteristic of the members who participate in the program implementation. Individual commitment can often supply the energy required to enable a program to be successful.

The designed intent of the group centered method is to reduce conflict through possibility thinking discussions to reach consensus results. It stimulates creative change by turning obstacles into challenging opportunities (Wenig, 1980, pp. 14, 15).

**THE CURRICULAR COMPONENTS**

In addition to establishing the proper group climate, an adequate structure is also required to obtain specific results (Watson, 1978). The model adapted from Tyler's and represented in Figure 2-1 can provide a process structure to ensure that all important curriculum elements are included in the elementary school technology education program.
Each of the elements is important for the development of a sound curriculum. However, the aims and goals are particularly important to establish. The aim of the elementary school technology education cur-
Curriculum is to develop an understanding and awareness of the technology which supports daily life. Representative curriculum goals are listed in Table 2-2.

**TABLE 2-2**

**CURRICULUM GOALS**

The following nine curriculum goals constitute the thrust of this program in contributing to the development of individual potential within the technological domain of our culture.

1. The development of technological literacy—vocabulary and the ability to communicate [graphs, flow charts, PERT, visually, etc.] and to develop a corresponding fluency in the understanding of technology.

2. The development of viable consumer skills—product testing, comparative analysis [children are definitely consumers as witnessed by the advertising aimed at the children’s market].

3. The encouragement and support of recreational expression—effective use of leisure time and the development of a sense of recreation is an important goal of our program as a foundation for lifetime attitudes.

4. The facilitation of cultural efficiency within the technological domain of our culture—how things work, where they come from, and how they are used, constitute an important part of living in our culture. A technological competency facilitates efficient living in our culture.

5. The development of occupational awareness—recognition of the many diverse occupations in our culture and the interdependency our society has upon each occupation.

6. The realization of self—the impact of the technological process upon the individual to help the child to gain an identity and recognize talents/abilities, and realize potential and contributions to a positive self-concept.

7. The development of values to assess the appropriate use of our technology and resources in our high technology systems [some of which are intrinsically dangerous, such as nuclear power], consideration of alternative value structures seems inevitable with regard to the future.

8. The recognition of technology and its effects upon the individual, society, and the environment.

9. The development of a time perspective continuum—the ability to learn from past ways of doing things and the effect upon previous culture; a sense of our contemporary culture and current issues; and the ability to project current trends.
IDENTIFYING THE CONTENT STRUCTURE

Content models (Figure 2-2) are useful to supply structure and to assist in the identification of technology education content. The Lauda/McCrory Model (See Chapter One, Figure 1-2) has proven to be a useful tool for elementary school teachers to allow them to efficiently conceptualize the scope of technology education content. When elementary teachers are able to conceptualize the content structure of technology, they can effectively:

- identify the dimensions of the study of technology
- recognize technology-based content
- select appropriate learning activities to reinforce technological concepts.

![Diagram of content structure](image)

**Figure 2-2. A curriculum content structure for Technology Education.**

The elementary school curriculum should provide a broad general understanding and awareness of technology. Figure 2-3 presents an expanding awareness of the study of technology.
FIVE DIMENSIONS OF THE STUDY OF TECHNOLOGY

Figure 2-3. The five dimensions of the study of technology beginning with the totality of tools and their identification. Each concentric circle represents an increased awareness of the study of technology. To present a complete study, each of these levels should be evident in the elementary school technology curriculum.

Beginning with tools and their identification, each concentric circle represents an increased consciousness about technology. To present a complete study, each of the dimensions of technology should be evident in the elementary school technology education curriculum.
SEQUENCING THE INSTRUCTION

The elementary school technology education program is interdisciplinary in nature, harmonizing with the existing curriculum. It serves as a reinforcing, unifying, and integrating factor in augmenting the elementary school curriculum while providing the opportunity for students to apply knowledge gained in many subject areas in a functional manner. The curriculum content selected from the discipline of technology can be sequenced by identifying themes for each grade level.

Themes and Activities

The following themes and related activities are suggested as representative of appropriate grade level experiences K-6:

K The technology that we see and use every day. Students listen to selected readings such as: Who Are the People in Your Neighborhood? What Do People Do All Day?, and Things That Go. Students manipulate a wide variety of local materials while considering where they come from and how we use them.

1 Technology in our home. Students identify and use common tools found in the home environment: telephone, typewriter, electric mixer, etc. Students plan and prepare food recipes and publish a collection of children’s recipes.

2 Technology in our community. Students identify the location of selected community resources and services and prepare a map or directory of services that children use.

3 Technology in our world. The adaptive systems of humankind and the material requirements for sustaining life are explored by students through role-playing the lifestyles of different cultures while considering the effects of various environments.

4 Technology and history. Students consider our technological heritage and the formative role it has played in shaping contemporary ways of doing things. Visiting museums and local historical sites, documenting the oral history of an industry, and constructing working models are some of the activities employed.

5 Technological and natural systems. Students explore the ways in which humankind uses the environment and the relationship between natural and technological systems. Construction of a solar reflector, sun clock, etc., can be used to explain the workings of our solar system.

6 How technological systems and devices work. Students investigate the interface between manufactured and natural
environments. Students construct displays and model selected ways of processing natural resources; values related to the use and management of technology are considered.

**Developmental Needs**

Sequencing must also consider the developmental needs and abilities of the learner. Developmental theory can supply the context for sequencing elementary school technology activities.

Havighurst provides a useful list of developmental tasks to use in sequencing activities.

1. Learning physical skills necessary for ordinary games.
2. Building wholesome attitudes towards oneself as a growing organism.
3. Learning to get along with peers.
4. Learning an appropriate masculine or feminine social role.
5. Developing fundamental skills in reading, writing, and calculating.
6. Developing concepts necessary for everyday living.
7. Developing conscience, morality, and a scale of values.
8. Achieving personal independence.
9. Developing attitudes toward social groups and institutions.

(Havighurst, 1972, pp. 19-33)

During the concrete operational period (age 7-11), the child's reasoning powers are limited to concrete experiences or images of concrete objects. Young children have to learn through real actions performed on things whether these be blocks, dolls, or foodstuffs. "What children acquire through active manipulation of the environment is nothing less than the ability to think" (Elkind, 1974, pp. 52-53).

Erikson identifies the school age child as primarily involved in the fourth level of his paradigm with regard to personality. Within the fourth level, Industry vs. Inferiority, the child learns to win recognition by producing things. The child develops industry; that is, they adjust to the inorganic laws of the tool world. They have the potential of becoming an eager and absorbed unit of a productive situation. Their danger at this stage lies in a sense of inadequacy and inferiority. (Erikson, 1950, pp. 224-227)

With regard to morality, it is the morality of authority which tends to dominate young children. However, as the peer group becomes the dominant influence, it is the morality of mutuality which tends to predominate. During middle childhood the magnitude of the infraction is a prime determinant of the severity of the crime; whereas in later childhood, the child begins to assess the motive behind the crime to determine the just punishment (Elkind, 1971, p. 57).
Kohlberg's system is compatible with Piagetian theory. The elementary school child at the concrete operational level exhibits behavior explained by the first four stages of Kohlberg's system (Sigel, 1977, p. 87).

Preconventional Level.
Stage 1. The punishment and obedience orientation.
Stage 2. The instrumental relativist orientation.

Conventional Level.
Stage 3. The interpersonal or "good-boy-nice-girl" orientation.
Stage 4. The law and order orientation.
(Kohlberg, 1976, pp. 572-576)

The elementary school age child is naturally interested in developing their skills. Athletic prowess is one area through which the child can achieve prestige. Other skills involve the self-help skills: eating, bathing, dressing, and the grooming of one's self. Social help skills may involve: making beds, dusting, sweeping, helping to construct a tree house, or the laying out of a baseball diamond. School skills may involve: writing, drawing, singing, clay modeling, painting, dancing, sewing, cooking, and woodworking. Play skills naturally develop coordination in the throwing and catching of balls, riding bicycles, skating, and swimming (Hurlock, 1975, p. 125).

Montessori identifies the role of education — to interest the child profoundly in an external activity to which they will give all their potential. For elementary education she would revive the idea of Comenius — by bringing the world itself to the child. Accordingly, every self-respecting modern school must have a museum. Through such a display, the student could experience history, anthropology, and artifacts firsthand. Montessori would have the child to study their environment to understand natural relationships and to experience choice and decision making skills to ensure responsible action (Montessori, 1973, pp. 25-34).

ORGANIZING LEARNING ACTIVITIES

Existing elementary school textbooks can often provide the context for Technology Education interdisciplinary activities. The aim of the elementary school Technology Education program is to develop an understanding and awareness of the technology which supports daily life — how does technology work and how does technology affect everyone? These are the basic understandings about technology that elementary school students should learn. Social studies can provide the opportunity to explore the history of technology and its social impact; science can provide an explanation for the feasibility of certain tech-
nological developments; and English can provide a base for creative writing exercises in the technology area, the opportunity to publish news, and experiences in technical writing. It is suggested that interdisciplinary units be developed using the “curriculum webbing/sunburst” (Figure 2-4) technique to establish the relationships between technology and other unit elements. It is considered that the use of this technique contributes to the development of the full education potential of Technology Education units in the elementary school.

An application of the sunburst technique is illustrated in Figure 2-4 utilizing a common elementary school theme of the life of the Plains Indians. Contributions of the study of technology to this typical theme are:

- Recognition of technology and its influence. Specific aspects of the Plains Indian technology were discussed, simulated, and modeled.
- Comparison of different levels of technology. With dramatic effect, white man’s technology interfaced with the Indian’s in the form of the train. The potential, advantages and disadvantages were compared, and the impact of each was discussed.
- Construction, problem solving, and planning opportunities. The construction of a display containing a train bordering on an Indian village afforded opportunity for research, problem solving (e.g., how to provide running water to the display), how to divide the construction responsibilities among class members, how to make the display communicate effectively to other students, etc.

Interdisciplinary units provide the means for organizing learning activities and for incorporating technology into classroom experiences. Technology can contribute in three ways to the development of an interdisciplinary unit: it can provide the theme for the unit; it can function as one part of the unit; or it can lend its process to the unit.

Three steps are recommended in the development of interdisciplinary units.

1. Select and identify technological content that falls within the structure presented in Figure 2-2.
2. Develop the unit using the “curriculum webbing/sunburst” technique, Figure 2-4, to establish the relationships between technology and other unit elements.
3. Present the unit using a problem solving approach.

Five steps are used in presenting learning activities using this approach:
Figure 2-4. Curriculum webbing/sunburst technique.
1. define the problem
2. ideate (brainstorm)
3. select a likely solution to the problem
4. implement the proposed solution
5. evaluate the solution.

Each of these steps may be repeated in a continuous cycle to develop the most appropriate solution to a particular problem. This approach allows students to become involved in the learning process by applying their individual talents, and also encourages them to become responsible for evaluating their own progress, because it is clearly evident when a workable solution has been developed.

The problem-oriented approach to instruction is derived from the problem-oriented nature of technology. Students enjoy this method of learning and find it challenging. Problem solving and the subsequent exploration and discovery affords them opportunities to consolidate their knowledge in unique ways through application to the solution of a real problem. The creative solutions employed by students make a challenging impact upon teachers, contributing to the dynamics of the learning environment.

An interdisciplinary example of a problem solving activity using science and technology is illustrated by the following fifth grade science unit on the human heart. Bio-technology is a contemporary example of the merging of scientific and technological activity and can provide a unifying context for this joint effort.

To initiate the project, the problem of constructing a working model of the heart can be assigned. See Figure 2-5. Many types of pumps could be developed. However, to be judged successful the pump should be able to operate in the same manner as a human heart. To solve this task, knowledge from science has to be collected, organized, and applied to the stated problem.

One successful solution used a sandwich bag for the heart, aquarium tubing for the arteries and veins, and balloons for the valves (Peterson, 1979, p. 28). To operate the heart, the hand is used as a heart muscle to initiate the pumping action. The pressure on the system can actually be felt, resulting in an increased understanding of blood pressure. The balloon valves allow the flow of liquid to occur only in one direction, just as in the human heart.

Much can be learned about science and technology through the process used in this project. In science, concepts such as natural systems, blood pressure, the cardio-vascular system, and the heart were developed. In Technology Education programs, concepts such as man-made systems, pumps, valves, fluid systems, and uses of pumps can be developed. Perhaps more importantly, additional knowledge was
realized through the synergy of teaming two related disciplines. Relationships and associations were realized that would not have been discovered through study in an individual subject alone. Through joint interaction it was realized that many natural phenomena have a technological corollary and nature may have provided the first examples for technological development. Several analogies could provide additional topics for teamed exploration — ears (amplifiers, musical instruments), eyes (lenses, optics, cameras), and bio-mechanics (arms as levers).

It is important that the learning activities contribute to the development of an understanding of the whole of technology. Since learning activities often constitute the major vehicle for the development of technological understanding, the selection of appropriate activities is vital to the accomplishment of technology education curriculum goals.
Table 2-3 lists some sources for learning activities which would be valuable for the implementation of technology education elementary school programs.

**TABLE 2-3**

**SOURCES OF LEARNING ACTIVITIES**

**References: Learning Activities**


Text, activity manual, and a guide for teachers containing information on energy/power, manufacturing, construction, transportation, and communication.


This book presents a collection of working solar devices to cut out and assemble. *Solar projects* is designed to let the reader explore some practical solar energy uses through a hands-on approach. It provides easy-to-construct, yet workable activities that are fun to assemble and instructive.


A text, activity manual, and a guide for teachers which focuses on people, their hand and machine tools, and the development of their technology.


Collection of creative technology-based ideas for learning activities.


A text with approximately 60 technology-based learning activities which could be adapted for use in elementary school classes.


*Connections* is a curriculum in appropriate technology for 5th and 6th grade students. Ten lesson plans are presented with handouts and suggested classroom activities.


Text and learning activities developed for the elementary school. Handouts and learning center ideas are included.
A classic text which is "must" reading for anyone developing a technology-based elementary school program — suggested learning activities are included.

A booklet containing 10 experiments related to Edison’s inventions. Other booklets including experiments related to nuclear energy are also available from the same source.

Contains activities developed by elementary school teachers. Other curriculum materials for grades 1-6 are also available from the U.S. Department of Energy.

**References: Programs/Organizations**

Creative Education Foundation, Inc. State University College at Buffalo, 1300 Elmwood Ave., Chase Hall, Buffalo, NY 14222.
Textbooks, and resource manuals containing ideas for activities related to creativity and invention are available.

Olympics of the Mind, c/o Sam Micklus, Professor, Department of Industrial Education and Technology. Glassboro, NJ 08028.
An innovative program co-developed by Dr. Micklus. The process used in this program could be adapted for use in elementary programs.

Technology for Children [T4C], Teacher Center, New Jersey Residential Manpower Center, Plainfield Avenue, Edison, NJ 08817.
A teacher center full of exciting technology-based activities for elementary schools. "T4C" also publishes a catalog of learning activities.

Unified Science and Mathematics for Elementary Schools [USMES]. Education Development Center, 55 Chapel Street, Newton, MA 02160.
A core curriculum project which uses technology-based activities. Activity-based resource manuals are available.

Workshop for Learning Things, 5 Bridge Street, Watertown, MA 02172.
An organization which presents workshops and also has an outstanding catalog for technology-based elementary activities.
**Facility Requirements**

The elementary school facility must provide the environment to stimulate creative thinking and house the resources to support learning activities. A creative environment suggests:

- pleasant surroundings — a colorful interior, interesting wall posters
- working models of machines which can be taken apart and put together
- exciting books which show how things work
- tools and materials that can be used to build things and model feasible solutions to technical problems
- display areas for student projects and collections of tools, machines or products.

Representative activities may include reading, drawing/sketching, taking things apart and putting them together, group discussions, constructing models, product testing, evaluation of proposed designs, and building informational displays. Problem solving activities may begin with the question, “Can I construct an effective wind measuring device?” or “How can I build a vehicle to safely carry a liquid from point A to point B in the shortest period of time?” Representative tools and materials which can be manipulated easily, safely, and independently by elementary students are preferred. To be successful, the laboratory must stimulate creativity, challenge students to explore new ideas, and motivate students to find successful ways to make their ideas work.

**Media Resources**

Media resources are essential for the support of meaningful elementary school technology education program. Existing resources should be evaluated for their relevance to transportation, communication, manufacturing, and construction systems and a plan developed to strengthen technology-related holdings. The following types of books should be included:

- How to build/make things
- Inventor/inventions books
- How/why things work books
- Why buildings stand up
- Construction toys/games
- Repair books/bicycles
- Printing/photography
- Toys you can build
- Games you can make

- Electricity experiments
- Learning centers
- How common products are made
- Bridges
- Trains, cars, trucks, boats, planes
- Paper airplane books
- How to make musical instruments
- How to build a kaleidoscope
SUSTAINING THE PROGRAM

Sustaining the elementary school Technology Education program is a function of student successes and the sense of accomplishment which teachers in the project team have gained. Student successes can be documented through pictures and anecdotal records of student comments/behavior. It is suggested that periodic reports of progress be made. These reports/presentations serve the function of documenting the successes that have been achieved, help to serve as a base for other presentations to local, regional, or national groups, and provides recognition for individual members which contributes to a sense of group accomplishment. Presentations also provide a means to publicize the elementary program, promote the local school, and contribute to program visibility. Encouraging each member to contribute and receive recognition for their accomplishment is an important key to continued program success and to assure that the benefits of technology-based education are available for elementary school students.

Funding

It is recognized that funding can provide a strong impetus for program development. Funding can also be an important ingredient in sustaining program success. Securing funding is often a time consuming, very competitive process. It is recommended that beginning implementation efforts be directed toward securing funding and support from the most available, local sources.

Local funding, although it may be limited is often the easiest to secure, may require less documentation than national sources, and is probably the most appropriate funding for initial implementation efforts to support feasibility studies and pilot programs. The successful attraction of local funding provides the opportunity to demonstrate success and establishes the credibility which may be required for attracting the additional funding needed to continue program development. The following sources of funding should be explored.

Local Education. Building principals, curriculum consultants and directors, boards of education, superintendents of schools, and PTA/PTO groups are some of the intra-system sources which may be able to provide limited support for the development of innovative activities which result in a positive learning environment. Initiative is valued and may be rewarded if a well conceived plan is developed and presented. An advantage of proposing technology-based programs is that many people recognize its importance and are supportive of efforts to promote the study of technology and its concepts.
Professional Organizations. Professional education associations are an additional source for funding support. Advising colleagues of funding interests, expressing your willingness to participate in proposed development, and asking to be advised of grant opportunities may help to obtain the required support. Contact with college/university or state curriculum consultants may also be profitable by expressing a willingness to participate in the development of appropriate curriculum activities.

Engineering associations, trade associations, and business associations may also be willing to provide support if contacted. These professional associations sometimes have educational efforts related to their interests.

Business and Industry. Local manufacturing enterprises and community businesses may provide tools, equipment, or material donations to build good public relations. Business and industry public relations and personnel directors can be valuable contacts for the support of local technology-based educational efforts.

Civic Organizations. The Chamber of Commerce organizations and other civic groups are often very supportive of education.

Federal Government and Private Foundations. Ask someone in the educational system who monitors grant opportunities to keep you apprised of funding opportunities. Table 2-4 lists some references as possible sources for funding.

**TABLE 2-4**

**SOURCES OF FUNDING**

*Annual Register of Grant Support.* Marquis Who's Who, Inc., 200 East Ohio Street, Chicago, IL 60611.


Illinois Research Information System (IRIS). University of Illinois at Urbana-Champaign, Research Services Office, Urbana, IL. *Support and Time*
Support is available but it does take time to develop a network of contacts to advise of opportunities and respond to requests for proposals. Persistence and initiative usually pay off. It is suggested that programs begin by committing available resources to demonstrate program effectiveness. After some success is achieved, a broader base of support can be obtained to sustain and expand curriculum efforts.

**SUMMARY**

The place to begin to develop an understanding of the technological systems we depend upon is the elementary school. Elementary age students encounter technology in their daily lives and have a natural curiosity about the communication, construction, manufacturing and transportation systems they use. Sample topics that can be addressed in the elementary school are:

- How is water delivered to our homes?
- How are our energy needs produced?
- How are our homes constructed?
- How are essential consumer goods manufactured?

Technology education in the elementary school is typically implemented through elementary school classroom teachers. It is important to be able to merge elementary school and Technology Education philosophies. When this merging occurs, the established Technology Education curriculum goals will reflect the character of the elementary school and result in an increase in teacher identification and program effectiveness.

The identification of appropriate content is an important function which must be performed to integrate Technology Education within elementary classes. The content models described in this chapter have proven useful for this purpose. A unique feature of the elementary school technology program is the close integration of content from many subject areas. The sunbursting process allows this integration to occur. Technology Education content should be developed around typical elementary school themes abstracted from existing textbooks and resources. Sequencing Technology Education instruction can pose a unique problem due to the wide range of abilities present in the elementary school. The spiraling curriculum approach using the basic concepts — communication, construction, manufacturing, transportation — can provide opportunity for the periodic amplification and reinforcement of these concepts. Grade level themes and developmental tasks can help teachers to provide sequentially planned activities.
The instructional methodology suggested is based upon the character of the technological process itself and provides specific guidelines for the implementation of the elementary school technology program. Beyond initial implementation efforts, it is important to be able to continue the program. To conclude this chapter, the value of publicity, documentation, and group accomplishment was described as they relate to sustaining the elementary school technology program.

The development of a Technology Education curriculum for the elementary school can be a rewarding, satisfying experience. Curriculum developers are encouraged to provide Technology Education elementary school programs. Technology Education programs are essential for students to apply knowledge in a creative and useful way, and to learn about the most powerful single factor influencing society — technology (Lenski & Lenski, 1978, p. 36).

REFERENCES


REFERENCE NOTE

To understand the middle school concept it is necessary to begin by reviewing the early development of its organizational structure. In the late 1950's and early 1960's, there was increasing criticism of the junior high school. It was viewed by many as housing the wrong groupings of students with the ninth grade viewed as a component of the high school, rather than the junior high school. Criticism was expressed that the junior high school had lost sight of its transitional function and that it had become too subject-matter oriented with a resultant lessening of concern for the needs of the student. Most of these criticisms could be summed up in the often-heard belief that the junior high school had become merely what its name implied, a junior high school, an imitation of the high school.

There was mounting evidence to indicate the children of the times were maturing earlier, both physically and socially. More rigorous educational programs were being advocated for ninth graders. At the same time, younger students needed a program that was truly transitional in nature. The Sixth grade children, though only two or three years younger, were noticeably less mature than the ninth graders. These younger children were also going through the rigors of early adolescence that made them quite different than older children who had already passed through this stage. From this, there emerged the now widely adopted middle school, spanning grades six, seven, and eight.

Many writers suggest less educationally sound reasons for the development of the middle school than those previously mentioned. McGlassen (1973, p. 14) points out:

Although in each district an educational “case” has no doubt been built for the organizational pattern, the fact remains that in almost every instance the pattern results from influences other than the educational program, usually building facilities and enrollments.
Popper (1967, p. 48) suggests that pupil retention was one of the several functions of the middle school, but this was later eliminated by modern compulsory attendance laws. In recent years we have seen schools reorganized for the purpose of changing social patterns within our society. Most prominent is the use of bussing to bring about racial integration. The neighborhood school has given way to the racially mixed school with children bussed, often over long distances, to bring about a desired balance.

Regardless of the initial intent or motives for establishing some middle schools, this organization does have an important place. If the function of the middle school were to be summarized in one word, that word would be "transition", because the middle school is an organizational pattern that offers the opportunity to develop educational programs that meet the transitional needs of the early adolescent child.

In a discussion of the philosophy, program, and organization of the middle school, Batezel (1968, p. 487) points out that: "A good middle school ought to provide for a gradual transition from the typical self-contained classroom to the highly departmentalized high school." Batezel lists an advantage of the middle school as providing for gradual change from the self-contained classroom to the complete departmentalization found in the high school.

But this transitional nature must not be thought of just in terms of transition from one classroom organization to another. More importantly, it is a transition through that period of physical and psychological change we call adolescence. Batezel (1968, p. 487) further points out that:

The middle school ought to exist as a distinct, very flexible, and unique organization tailored to the special needs of pre-adolescent and early adolescent youths. It ought not to be an extension of the elementary nor seek to copy the high school... The middle school ought to provide an environment where the child, not the program, is most important and where the opportunity to succeed exists...

This also supports the transitional function of the middle school. Popper (1967, p. 48) presents a definition of the differential function of the middle school and a guiding definition of the American middle school's paramount goal in the modern era:

The differentiated function — hence, the paramount goal — of the American middle school is to intervene protectively in the process of education which has begun in the elementary school, mediate between the human condition at the onset of adolescence and the pressures of culture, and continue the general education in a psycho-
logical environment which is functional for learning at this stage of socialization. McGlasson (1973) states that...classic statement of junior high school functions, excluding the early writers, was that of Gruhn and Douglass in 1947, still referred to in almost all writing about junior high and middle schools. (p. 20)

These functions were modified in 1970 to reflect changes in the thinking of educators. As stated by Gruhn and Douglass (1971, p. 75), "The functions of the junior high school today may be summarized as follows: (a) Integration. . .(b) Exploration. . .(c) Guidance. . .(d) Differentiation. . .(e) Socialization. . .(f) Articulation. . ."

It is evident that, even in this brief review of the purposes of the middle school, consideration of the child cannot be circumvented. The two, the school and the child, are inseparably intertwined and must be considered together. One cannot exist without the other. These six functions, when considered within the contexts of the nature of the school and of the child provide a useful organizational scheme for developing middle school curriculum. They give direction to curriculum planning, teaching-learning activities, and contain relevance for the study of technology in the middle school. The summarization of functions presented here provide a framework for justification of the technology education middle school curriculum that follows.

The socialization function of the curriculum implies the need to prepare the students to enter adult society. A widely accepted goal of education, to prepare the child for entry and effective participation in society, is particularly important in the middle school. It is during this time when the early adolescent children are developing and learning their unique ways of fitting into society.

Articulation or the transitional function of the middle school implies a structure or organization that will facilitate the gradual movement of the student from elementary to high school. The sixth grade would be characterized by pupil-teacher relations (approximating the closeness developed in the self-contained elementary classroom). As the student progresses through the middle school, the program would take on more of the characteristics of the high school with increased specialization.

Differentiation in the middle school curriculum accounts for the widely varying interests, background, abilities, and needs of students. This diversity requires a differentiated curriculum because a single pattern or organization cannot be effective for all. Flexibility and adaptability in curriculum content and teaching methods are important for the early adolescent.

The guidance function of the middle school takes on added importance when the students are treated as individuals, each with their own
interests, motivations, problems, and goals. Transition can be much more effective when done with careful guidance. Students must be assisted in making intelligent decisions concerning possible future career choices. Personal and social action, so important at this age, may also require adult guidance. The early adolescent often can benefit from guidance as choices are weighed and decisions are made and carried out.

The student needs the opportunity for exploration rather than being presented with a rigidly structured "cookbook" type of learning. Special and individual needs, talents, interests and abilities must be realized. The students are developing vocational and avocational interests that should be explored. This is a time when possible areas of interest should be tried. The discovery of dislikes is as important as the discovery of areas of interest, aptitude, and compatibility.

Integration of learning activities, materials, and content should be an important part of middle school curriculum. Compartmentalization and fragmentation should be avoided, especially at the sixth grade level. Students should be encouraged to apply skills, attitudes, and knowledge acquired in the elementary grades. Acquisition of a broad general education leading to a well integrated behavior in later life should be a primary goal. The curriculum should be characterized by widely ranging interdisciplinary activities crossing the lines of the traditional areas of learning.

TECHNOLOGY EDUCATION CURRICULUM

Five characteristics of a middle school technology education curriculum can be extrapolated from the foregoing. The curriculum should be: (a) exploratory, (b) understanding, (c) broad and fundamental, (d) interdisciplinary, and (e) vertically integrated. (See Fig. 3-1, p. 74)
<table>
<thead>
<tr>
<th>EXPLORATORY</th>
<th>6th grade</th>
<th>7th grade</th>
<th>8th grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognize wide range of student interests</td>
<td>Students explore production, power &amp; transportation and communication systems</td>
<td>-Study of variety of materials &amp; the processes of working with them. Humans use materials to improve their life on earth</td>
<td></td>
</tr>
<tr>
<td>-Provide variety, flexibility of materials used &amp; concepts learned</td>
<td>-Systems of technology-Power &amp; Transportation, Comm., Processing, Manufacturing, Const.</td>
<td>-Elements of technology operate in certain ways to result in consequences for humans - Conceptually based</td>
<td></td>
</tr>
<tr>
<td>BROAD &amp; FUNDAMENTAL</td>
<td>-Develop understanding that Technology is human-created. Answer, &quot;What is Technology?&quot;</td>
<td>-Technology-Science-Humanities are inter-dependent: each contributes and depends upon the others-</td>
<td>-Science of materials -Physics of processes -Social impact of Technology -Consequences of Technology</td>
</tr>
<tr>
<td>-Conceptually based</td>
<td>-Conceptually based</td>
<td>-Conceptually based</td>
<td></td>
</tr>
<tr>
<td>INTERDISCIPLINARY</td>
<td>-Study of technology can reinforce learning in social sciences, humanities, natural sciences</td>
<td>-With basic understanding of the nature of technology acquired in grade 6 - study can begin to be more specific - The Study of Technological Systems</td>
<td>-Increasing specificity</td>
</tr>
<tr>
<td>VERTICALLY INTEGRATED</td>
<td>-Transition from learning reinforcement function of the elementary school study of technology to more narrow, specialized study</td>
<td>-Beginning understanding of the nature of technology acquired in grade 6 - study can begin to be more specific - The Study of Technological Systems</td>
<td>-Increasing departmentalization -Increasing student responsibility</td>
</tr>
<tr>
<td>UNDERSTANDING</td>
<td>-Close pupil-teacher contact</td>
<td>-Increasing departmentalization</td>
<td>-Begin transition into high school</td>
</tr>
<tr>
<td>-Begin transition from elementary school</td>
<td>-Increasing student responsibility</td>
<td>-Increasing departmentalization</td>
<td></td>
</tr>
<tr>
<td>-Fast-paced, active</td>
<td>-Activity oriented - exploratory</td>
<td>-Recognize developing &amp; changing student interests.</td>
<td></td>
</tr>
</tbody>
</table>
Exploratory

Curriculum for the study of technology should be organized in such a way that the student is allowed and encouraged to explore many areas of interest. The changing, exploratory nature of the student must be considered. At this age level, there are great differences in interest, aptitudes, and maturation of the students. Exploration should be active in nature allowing the students to work with a variety of ideas, tools, materials, and processes. This assists students in making informed and meaningful choices of careers, avocations, and areas for further study and better understanding of their technological world.

The study of manufacturing is a good example of an exploratory activity. In such a study, students form a company, design a product, develop marketing strategies, manufacture the product, sell it, and finally, dissolve the company. Many and varied experiences are obtained, most of which are rather short in duration but intense in activity. These are necessary characteristics of any activity for this age youngster. In this activity, a strong foundation for later learning can be built along with the development of a better understanding of how our technological world works.

Understanding

Possibly one of the foremost considerations of the middle school is that it be understanding of the student. The humanistic or student oriented school environment is implied in nearly all other considerations. The varying interests, aptitudes, abilities, and maturation levels of the students must be considered as must the diversity within any group. The traditional middle school program is a student oriented program.

This demands that the teacher have a clear, in-depth understanding of this age child. The physical changes the child is experiencing and the social pressures being felt must be understood and considered in all educational planning for this age level. Also, there must be an understanding of the rapidity and frequency with which these changes take place.

The facility for the Technology Education program must be planned with an understanding of the children who will be using it: the eleven to fourteen year old who, above all else, is active and wants activity. The laboratory and equipment must be sized for children who will be working in it. Many students, especially those in sixth grade, will be small enough to need less than adult-sized tools, furniture, and equipment. It is possible that this ideal size will be somewhere between the small tools commonly used in elementary schools and adult-sized tools used in the high school.
The broad range of exploratory experiences mandates the study of a large number of materials using an equally large number of processes. The wide range of student interests and the need of variety and change in learning activities necessitate the use of a diversity of materials and processes. A "general shop" idea or multiple activities lab organization appears to be best suited to the middle school technology-based program.

**Broad and Fundamental**

Going hand-in-hand with the exploratory nature of the curriculum is the need for a broad and fundamental focus. A systems focus seems most appropriate and compatible with this transitional program. Inherent with this is the need to work in a variety of areas. This is also consistent with the changing and active nature of the early adolescent student.

Broad concepts should be learned at this level. Once mastered, these concepts become "hooks" upon which further learning can be hung and organized or classified. The broad and fundamental learning becomes a "skeleton" of knowledge and skills around which future learning is built.

For example, students studying solar energy could build a solar collector. This could begin as a simple box with a transparent top covering. When placed in the sun, the box will become warmer. Though quite simple, this illustrates some important concepts concerning solar energy. Students should begin modifications to this basic collector to improve its efficiency. The inside of the box could be painted black. Insulation should be added. Reflector panels could be added to the sides to concentrate more solar energy into the box.

Even with these modifications, the collector is not very practical. It collects heat as evidenced by the temperatures reached inside the box, there is no convenient way to use the heat. By pouring water through the box, students see that the water is heated, evidence of some collected heat. The addition of coils of metal or plastic pipe inside the box provides a more efficient way of handling heated water.

The manufacturing experience described earlier also can be considered to be broad and fundamental. The basic concepts such as interchangeability of parts, the use of jigs and fixtures, and organization for line production are certainly fundamental to understanding the nature of industrial production whether in an historical context of the industrial revolution or in a study of modern automated, robot-equipped industries. Such an understanding would certainly provide all learners with a better understanding of the importance of the work being done.

The study of energy and power can provide another example of activities which are broad and fundamental. A study of energy and
power should begin with consideration of the sources of energy: muscle, fossil fuels, nuclear, falling water, tidal, wind, geothermal, and solar.

The model airplane can be used as an introduction to the internal combustion engine. This simple, two-cycle engine is inexpensive, has a few simple parts, and is easily handled and stored by the students. A molded paper egg carton makes a simple but effective tool and parts box for each engine. Even with this simple engine several tests can be made. The RPM can be measured using an optical tachometer. The effects on engine speed of changing the air/fuel mixture, the use of different fuels, and size or pitch of propeller can be observed.

**Interdisciplinary**

The transitional function of the middle school also suggests the need for an interdisciplinary curriculum. As the students move out of elementary school, they need to understand the interrelationships among disciplines. They need to develop a wholistic view of their culture. School subjects are often taught as if they were totally unrelated rather than reflecting the interrelatedness that exists.

Technology does not exist as a separate entity but, rather, is infused throughout modern society. A Technology Education curriculum, of all the disciplines (possibly more than any of the others) must cross the artificial lines between disciplines.

Review of a popular middle school science textbook reveals many areas where the study of science and technology can be integrated. How better to learn the science of energy and motion than by building machines and mechanisms that have some utilitarian value? Laws and principles learned in the science class can be applied in the technology education class. Magnetism, electron flow, the movement of a wire through a magnetic field are principles learned in a study of electricity in a science class. These can be applied in the construction of generators and motors in the technology lab. A simple electric generator can be built. Changing wires in the generator turns it into a motor.

Nature and ecological studies in science can be enhanced by building devices using skills learned in a technology lab. A camera-tripping device can be built that will trip the shutter of a camera when an animal passes over the trip wire. Nets can be made for collecting insects or aquatic life. The current interest in energy offers numerous possibilities for interdisciplinary efforts. The solar collector described earlier can be designed around scientific principles, using construction techniques taught in the technology lab. Such work helps the student see the interrelatedness between technology and science. The hands-on activities provide basic skill development activities and the work with materials and processes which are such an important part of the study of technology.
It is unlikely that true interdisciplinary programs will occur naturally or that they will come about easily. A great expenditure of time and effort will be required, especially if resistance or reluctance to adopt the "new" approach is encountered from teachers. If technology teachers want to see such a program come about, they will have to take the initiative and provide the necessary leadership.

One way to start would be to review textbooks used by other teachers. What units of study lend themselves to the interdisciplinary format? From this review, ideas can be developed for the cooperative effort and suggestions made to the other teachers. Have specific suggestions in mind when making the initial contact. Show how learning will be enhanced for all students involved in all classes.

Show how work done in one class can be enhanced by work done in others. An ecology or environmental studies unit in science can be improved by photographic studies of the environment. The addition of nature, close-up, or microphotography activities would expand the scope of a photography course. Devices designed and constructed in an electronic communication unit could add greatly to the science program while their use would add meaning to the activities in the electronics class. Similar examples can be found in mechanics and power, light and photography, electrical theory and telecommunication, and heat and engines. Skills learned in the technology lab could also be used in constructing models in social studies. A simple line production activity could add great meaning to a social studies unit on the American industrial revolution.

An interdisciplinary approach is inherent in technology. The humanities, sciences, and technology are interrelated and should be learned in that way. The study of technology can reinforce the study of other disciplines. Concepts and skills of mathematics, the natural sciences, social sciences are used in many ways. Historically, technological advances often preceded a scientific explanation for the act. Today the theory and practice often go hand-in-hand.

**Vertically Integrated**

The transitional middle school organization demands a carefully planned and organized curriculum spanning the sixth, seventh, and eighth grades. There must be a sequence of learning experiences designed to carefully guide the students through this time of rapid and dramatic, personal and social change. Each stage in the curriculum should be built upon previous learning and, at the same time, should be foundational for learning which follows.

The sixth grade program is primarily exploratory in nature while, in the eighth grade, there is emphasis on transitioning into the high school. The program for each grade in the middle school should be
different as the needs of the students at each grade level are different. Included in the vertically integrated program should be increasing specificity, increasing student freedom, a teacher role moving from directive to helping and supportive, and a school organized to move the student gradually from the self-contained classroom of the elementary school to the departmentalized high school.

The study of technology in the sixth grade can be considered to be the foundational level. Though, ideally, there will be some technology study in the elementary schools, it is unlikely, for the present at least, that this study will be other than supplemental or reinforcement where the elementary teacher will organize most of the actual activities. For most students, the sixth grade study of technology will be their first organized study of the discipline with a specialized Technology Education teacher or facility.

It is important that this first exposure provide the proper foundation for further study. In the sixth grade, students need to develop understanding of the nature of technology — its materials, processes, methods, and impacts. Technology is a human creation. This must be understood for it is essential to an understanding of the concept of technology being controllable by humans.

In the seventh grade the study can broaden into a study of technological systems. This careful study can begin with a broad look at technology and then move on to more specific and detailed considerations of the systems. As students mature, study can become more complex. In the eighth grade, study can be concentrated more on materials and processes and their use in technological endeavors.

Where the previous elementary school study of technology had been for the purposes of reinforcing learning, study at this beginning middle school level is for the purposes of articulation into the technological world and exploration of that world. It is important first to develop an understanding of the true nature of technology. The question, “What is technology?” must be answered before further study can be meaningful.

From this early understanding, study in succeeding years can become increasingly specific. The seventh grade student can explore systems of technology. These broad conceptual categories become foundations upon which later study can be built. The eighth grade program continues the gradual transition to increased specificity with a study of materials and processes of technology, how they operate and the consequences for humankind.

Vertical integration is planned into shorter periods of time: a semester, unit of study, grading period, or even into a week’s activities. Each is planned so it follows the previous study and adds to the foundation. In a study of energy and power, for example, the students
begin with a study of the seven sources of natural energy. This provides needed perspective for later, in-depth, study of these sources. As each (solar, fossil fuels, etc.) is studied in more detail, its place in the total picture can be kept in mind by referring back to the earlier, broad study.

As students progress through their studies of energy and power, their work becomes increasingly complex. This progress could be through a series of units in a school year, a semester, or over several years. With the study of fossil fuels as an energy source, for example, the students progressively learn about simple internal combustion engines beginning with the model airplane engine. They then move on to more complex, such as two-cycle lawn mower, and then to four-cycle engines, and possibly later, in high school, to multi-cylinder engines used in airplanes, ships, and automobiles.

The preceding is a brief conceptualization of the nature and form of the study of technology in the middle school. The key element in this organization is the planned, progressive ordering of instruction and learning through a program from the first introduction through advanced, in-depth studies.

**CURRICULAR AREAS**

If we in Technology Education are to implement the philosophies and objectives we have been espousing for several years, the development of such a curriculum seems overdue. As we live in, and possibly beyond, a technological age, our schools must transmit this complex way of life. Students must be assisted in interpreting technology and their life in a technological world.

The exploratory technology curriculum can be organized using the four subsystems of human technological/sociological endeavor suggested in the "Jackson's Mill Industrial Arts Curriculum Theory" (Snyder & Hales, 1982, p. 20): manufacturing, construction, communication, and transportation. For ease of organization in teaching, it is suggested that these can be further divided into teaching units, each with identifiable and discreet content appropriate for study in the middle/junior high school. The following major teaching units are suggested: (a) processing, (b) energy and power, (c) manufacturing, (d) construction, (e) communication, (f) transportation, and (g) automation.
THE FACES

THE FACES ARE THE CHARACTERS, IDENTITIES, FORCES, WHICH TOGETHER CONSTITUTE THE TECHNOLOGY (18).

THE INTERFACES

THE INTERFACES ARE AREAS OF COMMONUNITY, OF UNITY, WHICH THE HUMANS MUST ESTABLISH IF THEY WILL LIVE IN HARMONY WITH TECHNOLOGY.

THE COUNTERFACES

FOR EACH FACE OF TECHNOLOGY THERE IS AN EQUAL BUT OPPOSING FORCE- A COUNTERFACE.

TECHNOLOGY
ITS FACES, COUNTERFACES, AND INTERFACES

Figure 3-2. Technology, its faces, counterfaces, and interfaces.
The study of technology could be introduced by asking and then answering the question, "What is technology?" In this unit some organizing structure or model such as Olson's "Eight Faces of Technology" (Olson, 1973) can be used. See Figure 3-2. Group studies by a class are organized to explore the meaning and impacts of technology. Studies by individual students can be organized to provide in-depth explanation of specific aspects of technology such as each of the faces, counterfaces, and interfaces in the Olson model.

**Material Processing**

In a study of processing, students are introduced to the changing of raw materials into usable form. Most materials are not useable as found in nature. Trees must be cut and made into lumber. Crude oil must be refined. Iron ore must be mined, refined, and made into cast iron or steel before products can be produced. The concepts of recycling and re-use are gaining importance as some of the non-renewable resources are being depleted. A structure of processing technology with three major sub-headings is suggested in Figure 3-3.

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**Figure 3-3. Structure of processing content.**
In both the pre-processing and post-processing stages there is need for storing and transporting the materials. These operations could logically be considered as transportation rather than processing functions though they are still necessary operations in the processing of materials.

Material processing is suggested as the first unit following the introduction because various materials (metals, paper, wood, petroleum, plastics, etc.) are necessary in all areas. In this area students study and experience several examples of processing. Refining petroleum products provides an example of processing of liquids that should have great interest in times of dependence on energy from petroleum. It is at this point that a more traditional introduction to basic tools will be introduced.

Paper making is a process easily duplicated in the school lab. The student-made paper could be used later when printing is studied as a method of communication. Paper making also is an area where the students explore the concepts of recycling/re-use of materials. Paper can be collected, chopped, digested, and made into "new" recycled paper.

In material processing, students will simulate many operations. It would be impractical to try to make steel, mine coal, or refine petroleum products. These could be studied and some foundational knowledge developed through group and unit studies, the construction of models, and the development of displays. A class may decide to study coal mining, for example, with sub-groups of students each studying one mining process such as strip mining, or the slope, shaft, or drift mines used in underground mining. Displays could be constructed that illustrate the methods. (See Maley, 1973)

**Energy and Power**

The study of energy and power can be organized into four major headings: (a) sources of energy, (b) conversion systems, (c) transmission systems, and (d) uses. It is important that all four of these be studied to gain a complete understanding of the topic. See Figure 3-4.

![Figure 3-4. Structure of energy/power content.](image)
The study logically begins with consideration of the seven sources of natural energy: muscle, fossil fuels, uranium, falling water, tides, wind, geothermal, and the sun. Each is important and should be studied. Though fossil fuels, uranium, and falling water are the most used sources of energy, the tides, wind, geothermal, and sun are important and should not be overlooked. An understanding of the advantages and disadvantages of each is also important.

Few of the natural resources produce energy in a readily useable form or in a place where it is to be used. Energy must be converted into a useable and transmittable form. Nuclear energy is used to convert water to steam. The steam drives generators and the electricity produced can be transmitted to places where it can be used. Similarly, coal or oil in its natural form has limited use. Both must be burned to make steam. Oil in the form of a fuel such as gasoline can be burned in an engine to produce the power needed to propel airplanes, ships, and automobiles.

Study of the transmission of energy should include learning about generators and motors; turbines; power plants; mechanical, hydraulic, and pneumatic transmission. This study should not be limited, as is often done, to working with internal combustion engines. Certainly these are important, especially as we recognize the limited supply of the sources we have traditionally depended on, but this should not be the extent of the study.

There are numerous learning activities in the study of energy and power. In the study of energy sources, various types of solar collectors are designed and built. Windmills are built and tested. Group and unit studies are used to explore and learn about nuclear, geothermal, tidal, and falling water sources of energy.

The conversion of energy has been a traditional area of study, mainly through study of the internal combustion engine. Other activities are equally important. Generators and motors can be built. These devices are important to the conversion of and transmission of electrical energy. A simple generator can be built, converted to a motor, and connected to a windmill to illustrate energy output. Bicycle generators can be powered by windmills and turbines of various types.

Steam turbines are important in the conversion of energy. Simple turbines can be built providing opportunity for testing rotor designs. It is possible to drive a simple generator with a student-made steam turbine to illustrate the conversion of heat energy from fossil fuels to electrical energy.

The study of internal combustion engines begins with the model airplane engine. Through the use of organized procedures for disassembly, the students learn the names and functions of the parts. This same procedure can be expanded as students move on to more complex engines.
Solid fuel rocket engines are studied through model rocketry. This popular hobby offers opportunity to learn about rocketry that is fundamental to space travel. The model rocket engines are tested on a test stand to better understand their operation. The study of rocket engines is combined with study of rockets and rocket-powered spacecraft in transportation vehicles. The engines become an important part of the study of power plants used in transportation.

The mechanical transmission of energy is explored through study of levers, belts-and-pulleys, gears, sprocket-and-chain systems, and fluid power systems. These studies take several forms. Best known are the training units designed to provide the hardware necessary to experiment in hydraulics and pneumatics. Similar units are available or constructed for mechanical transmission of energy. These contain an assortment of gears, pulleys, sprockets, and chains necessary to construct a variety of mechanical devices for testing and experimentation.

Students can construct machines which illustrate mechanical and fluid transmission of energy. Inventing, researching, and developing simple machines could be an interesting method of making mechanical devices. Devices needed in a mass production activity (manufacturing) could provide desired learning and experiences with the added value of having a practical application.

The use of energy is explored through several activities. A home energy audit is conducted to determine the energy used in the home. Students study electric, fuel oil, and gas bills to determine the amount of energy used. Projects are undertaken to discover heat losses in the home during the winter and attempts to reduce these losses. Energy use is measured again to check for improvement. An automobile driving record may be kept to determine how the family car is used. A plan is developed to reduce the amount of driving, thus, reducing fuel consumed.

It is recommended that the processing and energy/power units should be studied as prerequisites to the remaining units because both are necessary parts of all remaining studies. Materials and energy are necessary parts of manufacturing, construction, communication, and transportation. Knowledge and skills learned in these first two units will be used.

**Manufacturing**

Though any area could be considered next, manufacturing is suggested because manufactured products are used in all of modern technology. Understanding the production of products is important in all the areas of study. An understanding of the concepts, processes, and
organization of manufacturing is fundamental to the understanding of modern technology. Though there are several schemes around which a study of manufacturing can be organized, the structure by Wright (1977, p. 2) seems particularly useful. (Figure 3-5) This is simple enough to be understood and used by middle school students.

The manufacturing activity where students form a company, design and produce the product, and dissolve the company is probably one of the best known activities in modern industrial arts programs. Numerous books and journal articles have been written on it. Several research projects have been funded to develop extensive curricular materials. Therefore, it is not necessary to repeat this material here. The readers are directed to those materials for further information and assistance in developing a manufacturing activity for a Technology Education program in the middle/junior high school.

It is important to point out that even this well known activity is undergoing change. Modern "high tech" activities are appearing here as computer assisted design and computer assisted manufacturing (CAD/CAM), simulated automated equipment and the personal computer are introduced into the curriculum.

Construction

The study of construction is organized around several sub-systems. First, the various types of construction can be studied: dwellings, transportation (bridges, roads, waterways), and commercial structures (airport terminals, high-rise buildings, factories). Secondly, the materials and processes of construction serve as an organizational scheme. Study centers around tools and machines, materials such as lumber, steel, concrete, and ceramics, and the method of using these in building structures. The social impact of construction also is important in this study. Land use, zoning, efficient energy use, and mobility of people caused by construction all are important.
Figure 3-5. Structure of manufacturing content. [Wright, 1977, p. 2]
Figure 3-6 presents a suggested curriculum context matrix for the construction area. Though this is more extensive than can be considered in the typical middle/junior high school program, it shows the breadth of construction activities. In the middle/junior high school, a broad exposure is given and the unit of study can be centered primarily on residential construction. Most of the students relate to this and find many applications of the learning in their everyday experiences.

This is another area that has been developed extensively. Caution must be used to ensure that student activities in the construction area are not limited to carpentry in the form of building small structures.
to sell. As shown in Figure 3-6 much more than carpentry must be studied to gain a complete picture of construction technology. In addition to residential construction, students should study the construction of non-buildings such as dams, bridges, and roadways. Some consideration must be given to buildings other than houses. Commercial and industrial buildings are an important part of modern construction.

A construction unit could begin with a study of the organization of a construction business. A simple company could be formed, similar to the company in the manufacturing unit. Construction activities may begin with blueprint reading and surveying activities designed to give the students experiences with the layout of a building site and foundation of a building. Other experiences should include work with masonry, concrete, plumbing, and electrical wiring as well as carpentry.

Students learn to lay block and brick by laying a small wall in the lab. A cement-less mortar is used so the wall can be disassembled and the block and brick reused. The mixing and pouring of concrete is experienced through the pouring of patio blocks in a wooden form. Plumbing and electrical wiring is practiced in full-sized wall modules. Wall modules could have been built as part of a carpentry experience. All this can be disassembled for use by later classes.

Many instructors have had success with the teaching of construction — carpentry in particular — through the use of scale model building. Scale lumber (2 × 4’s, 2 × 6’s, etc.) are cut and students build wall sections or complete scale model houses using techniques that closely simulate those used in full scale construction. A scale of 3″ = 1′ (one-quarter size) is large enough to allow the students to nail framing together using standard nailing schedules. Trusses are designed, built, and tested if a research activity is desired. A scale of 1″ = 1′, (used for doll houses) has some advantage because there are many materials available in this scale used by the doll house builder. Using this smaller scale, students could build scale houses, community buildings, industrial parks, even an entire community in the lab. Such a community, as it grows and develops, may become the vehicle for studying transportation and communication systems such as power and telephone networks. This scale does have some disadvantages due to the small size which limits the simulation of full-scale building techniques.

Communication

The study of communication is organized using several different structures or models. Traditionally, it has been organized around the four areas of drafting, printing, photography, and telecommunication. Another organizing scheme uses a model which conceptually presents the communication process as shown in Figure 3-7.
Student activities in the communication unit are centered around the four technical areas: drafting, printing, photography, and telecommunication (electronic communication). These can be related back to the model of communication to show how each follows the model from idea to completed message.

In introducing this unit it is suggested that an historical approach be used. Early and simple means of human communication such as semaphore, smoke signals, Morse code can be used to develop student interest. The students transmit messages using these systems as an illustration of the communication model as well as illustrate the idea of communicating over long distances; the primary goal of communication technology. The students make semaphore flags and code practice oscillators and use them to communicate across the classroom or school yard. The Morse code can be transmitted over a radio rather than through wires. This could naturally lead to a study of radios. Simple radios are constructed which have a "modern" look if they are built around a printed circuit board. The complexity of this activity ranges from a simple one-diode radio to more complex receivers depending on the experience and abilities of the students.
Telecommunication should include experience with radio and television production. Students can write scripts, act out parts, and produce radio or television programs. Most schools today have video-tape equipment that can be used in a simulated television studio. If video-tape equipment is not available, radio programs can be produced using simple and inexpensive tape recorders. Both of these activities are organized to give students a close simulation of the organization of radio and television studios.

Graphic communication activities include various printing methods. Students write, edit, and print a class newspaper using the printing technique available to them. Offset, mimeograph, or the spirit duplicating process can be used for this activity.

Photography is a high interest activity in graphic communication. Students build simple pin-hole cameras to learn the basics of camera construction and operation. They move on to more complex cameras doing activities such as portrait, nature, or human interest assignments. The making of portraits with a simple portrait lighting set-up has a high interest for students of this age. Each student can take the picture, develop the film, and make an enlargement of a portrait for a classmate.

The drafting part of communication is tied in with construction or manufacturing. Also it can be introduced through the layout and design of printed matter in the printing unit. The use of drafting as a means of communication is necessary in all these areas and probably should be introduced where appropriate.

**Transportation**

The matrix shown in Figure 3-8 is used as an organizing model for the study of transportation. Land, sea, and air/space are categories of vehicle, power plant, control systems, and “the way” that can easily be learned and understood. When placed in a matrix such as this, students quickly visualize various elements of transportation and the interrelationships among them.

<table>
<thead>
<tr>
<th>The Vehicle</th>
<th>Power Plants</th>
<th>Control Systems</th>
<th>The Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Railway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conveyors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WATER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIR/SPACE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3-8. Content matrix for transportation.**
Student activities for transportation are virtually unlimited. The bicycle, primary mode of transportation for the middle school-age child, has great potential as a teaching/learning device. Students are taught simple use and care of a machine through maintenance and care of a bicycle. Road safety is taught along with the proper handling of bicycles. The sponsorship of “bike rodeos” takes advantage of the natural competitive spirit of students while teaching good bike riding skills.

Many students in this age group are also interested in airplanes and space travel. The theory of flight is basic to understanding how an airplane flies and can be taught with the building of kites. This is expanded into the construction of simple unpowered balsa or sheetfoam gliders and then into the construction of unpowered and powered airplanes.

The model airplane engines studied earlier are added to the models being constructed, thus, reinforcing the study of power plants in airplanes. Similar activities are developed for rocket powered transportation vehicles. The popularity of model rocketry is used to interest students in the study of model rocketry. Student-made rockets are powered by the engines studied in the energy/power unit.

The “way” is a term that may be foreign to the students. This refers to the road-way, the rail-way, the air-way, the water-way, or any route over which the vehicle travels. This opens the possibility of coordinating a study of transportation with construction. Roadways and railways are important to land transportation and are an important part of construction. Students, through a group or unit study, learn how roadways and railways are constructed and the importance and impact these have on communities. Similar studies are used to learn about the routing of airplanes and ships.

**Automation**

Automation, defined as automatic control, is a characteristic of modern technology. As such it is a necessary part of a study of technology. The components of an automated system are used as the organization structure for this unit. These are as follows:

- Action components — those parts of the system that apply energy to the system — motors.
- Controls — regulating devices such as switches, relay, solenoids, valves, etc.
- Sensors — detect and measure how the system is operating — thermocouples, gauges, meters, etc.
- Decision and Program — This is the “brain” of the automated system. It is also the part that makes the difference between
the mechanized system and the more complex automated system. A decision component — part of a computer receives incoming information, compares it with stored information and if needed, sends commands to controls in the systems.

- The stored information — the program contains information about how the system should be operating. This, also stored in the computer, is used to send information back into the system to cause changes to be made in the system.

**Consequences of Technology**

A concluding unit is organized to study the impact of technology. The "Eight Faces of Technology" model by Olson (Figure 3-2) can again be used. Each of the faces and counterfaces are used to study the interface of humans and technology. Each face and counterface includes the action and reaction of this human/technology interface.

Students study the effects of energy use, misuse, and possible shortage. The impact of modern transportation such as dependence of the automobile and the energy intensive nature of modern transportation systems. The impact of technology on work, leisure, culture, the environment, and nature can be studied.

**SUMMARY**

The curriculum suggested here presents only the barest of details. Limited space does not allow a day-by-day curriculum plan. In fact, such an approach is questionable because each teacher should develop curricula that are responsive to the students being taught and to the community supporting the school. One curriculum plan may not be suitable for all schools in our country.

At the same time this chapter is directive in the sense that suggestions are made to help the interested teacher to begin moving toward a Technology Education program in the middle/junior high school. The movement is still in its infancy as evidenced by the intent of this yearbook — helping the teacher implement Technology Education.

Though some limited curricular materials are beginning to appear, their number is limited to the point that the future success of the movement still rests with the classroom teachers. It is at the classroom level that Technology Education programs will be made or broken. It is hoped that this chapter will assist people who are working "in the trenches" to begin to take those first tenuous but very important steps in the direction of a program based totally on technology.
REFERENCES


Chapter 4

High School Technology Education

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As a result of the technology "explosion" over the past decade, a new revolution has evolved which places greater demands on public education to provide relevant educational programs. High schools are being looked upon as the institutions to prepare individuals for employment, general living, and higher education. The amount of knowledge present today has been forecast to double again in approximately eight years. This exponential growth rate of knowledge has further accelerated new innovations and broadened the gap between classroom subject matter and the technological realm. Because of the wide separation between reality and many present high school industrial arts programs, there is need to realign and upgrade content to be congruent with modern technology, thus establishing a rationale for Technology Education programs.

Implications of changing philosophy for program development in public schools is both challenging and extensive. High school Technology Education programs are now being structured around the study of four universal technical systems — communication, construction, manufacturing, and transportation. These systems provide the curriculum framework from which instructors can develop program models and initiate instruction. It is significant that practitioners understand a method that uses

- a systems approach in developing
- a curriculum for guiding the preparation, and
- instructional programs for technology education.

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The following chapter provides high school teachers with suggestions on how to perform these important tasks.

**A SUGGESTED RATIONALE**

The intent of high school technology education is to provide students with a course of study that will help them become knowledgeable of the technological environment in which they live. It is concerned with developing course curricula that provide young adults with preparatory skills to be contributing citizens, as well as improve the quality of life standards of the American society.

To begin the transformation from Industrial Arts to Technology Education, a rationale and an organized list of objectives are needed to provide guidelines for developing instructional content for high school curricula. Pioneers of Technology Education proposed this task be accomplished, during the Industrial Arts Teacher Education Fellowship Program in the Technologies, 1969-70 at the West Virginia University. This group stated the following:

> It is proposed that from technology there be derived a realm of study which should become a major concern of all public education. Its scope should encompass the interrelationship of man with his institutions, understandings, and abilities as a positive force in becoming all he is capable of being. (p. 4)

This insight into the study of technology has evolved in a heuristic manner producing an array of suggested objectives from concerned individuals throughout the industrial arts profession. From these suggestions, an organized list of objectives has been formulated to help high school practitioners comprehend the purpose of the Technology Education movement.

A high school Technology Education program should:

1. Further develop students' understanding of tools, materials, processes, and products that are part of the technological era.
2. Involve learning experiences through building projects, conducting experiments, and performing other laboratory activities in which students work and think together (interact, inquire, discover, problem solve, and decision make) to increase their cognitive, psychomotor, and affective abilities.
3. Provide a classroom setting which allows students to examine societal problems that result from people's use of technology.

4. Create student awareness pertaining to the causes and effects technological change proposes to business/industry, occupational frontiers, and cultures throughout the world.

5. Increase students' knowledge about the past, present, and future technological developments and the effects innovations propose to local and global communities.

6. Aid students in developing respect and responsibility of good citizenship to make sound assessment in determining what technology is appropriate for local and global usage.

7. Better equip students with skills to cope with cultural change caused by technological advancement.

8. Diversify students' skills in the universal technical systems (communication, construction, manufacturing, and transportation) for general living and vocational pursuits beyond high school.

9. Contribute to the development of technical and technological literacy within society which will provide its members with the knowledge necessary to understand the principles of technology.

10. Participate in multi-disciplinary activities in the school curriculum to illustrate the relationship of technology to other subject areas and provide students with the utmost Technology Education.

These objectives are a basis from which high school curricula may be developed. It is important when designing Technology Education programs that curriculum developers are from the local level. Special attention should be given to each local educational agency during the planning period to design a curriculum that will benefit students in each school individually and collectively. In general, students follow one of the four paths that are illustrated in Figure 4-1 (p. 98) upon their immediate graduation from high school.

At the time in which young adults leave secondary education, their knowledge base is the key to their success in whatever route they choose to travel. Some graduates will select a path and continue to travel it throughout life. Others may cross paths more than once. A percentage of high school graduates will never attend formal education beyond high school because of their social-economic condition or social attitude toward higher education. Because of this wide discourse which takes place when students depart from high school, content selected to edu-
cate students about technology must be thorough, yet flexible. The selection and presentation of content for Technology Education is a very important task.

STUDENT PURSUITS BEYOND HIGH SCHOOL

Figure 4-1. High school students follow one of four paths upon graduation. A technology education program helps prepare high school students to succeed in these directions because the student's affective, cognitive, and psychomotor skills are further developed in the areas of study. (Communication, Construction, Manufacturing, and Transportation.)
Modernization of high school technology programs requires the development of improved methods for processing information. The profession is in conceptual agreement that the determinants (sources) of curricula should include Humankind, Society, Technology, and the Environment. However, the challenges of processing appropriate information (knowledge, techniques, and values) into efficient and effective high school level educational programs requires much more attention.

The issue of how to develop curricula and instructional program has quickly moved to the forefront. Change is universally accepted. Noted futurist, Toffler (1980) suggests that world society has entered a new Age in which the heights of the industrial era are past. An Age of Information Processing (the electronic cottage) is present and future. A process must be established that allows a similar transition in high school industrial arts programs.

**Technology Education: Curriculum and Instructional Program Development**

The curriculum and instructional model proposed in Figure 4-2 (pp. 100-101) advocates a systems approach in modernizing high school industrial arts programs. It separates curriculum and instructional program development into sub-systems. Crucial determinants provide the source of information for curricula while the curriculum provides parameters and guidelines for instructional program development. Consequently, both curriculum and instructional needs are served through an approach which can be adapted to many situations.

As illustrated in Figure 4-2 (pp. 100-101), the systems model requires some additional explanation to expose its unique qualities of flexibility and adaptability. Conceptually, it is quite simple; yet, upon careful scrutiny, the reality of today’s highly complex technological society begins to surface.

In this model, due to the need for a highly sensitive process reflecting the state of humankind, society, technology, and the environment, several levels (sub-systems) are necessary. Additionally, each system and sub-system is comprised of several parts or elements. The elements include input (sources such as determinants for curriculum development), process (task analysis and actions), output (goal or end product), feedback (control), and modification. These basic concepts of systems theory are essential in understanding the operation of the proposed Model.

The overall Technology Education Systems Model is divided into two very distinct and interrelated sub-systems called Curriculum Development (Sub-System A) and Instructional Program (Sub-System B) respectively. Each will be presented and then discussed as interrelated components of an overall system.
A SYSTEMS MODEL

INPUT (DETERMINATES)

SUB SYSTEM A CURRICULUM DEVELOPMENT PROCESS

ENVIRONMENT

TECHNOLOGY

SOCIETY

HUMAN

INCENTIVE COMMITTEE

Classifications
- Mission and Goals
- Population Served
- Content Organizers
- Intended Learning Outcomes
- Continuum
- Modules, Subjects and Sequences
- Gaps and Overlaps
- Articulation
- Guidance

Verification
Figure 4-2. An illustration of a systematic approach for curriculum and instructional programs development.
Curriculum Development Sub-System

The goal of the Curriculum Development System is to provide written documents or publications for each model and/or subject to be included in the Technology Education program. This presents a difficult and complex challenge in which many issues must be identified and resolved. Therefore, an information processing, decision-making "nerve center" for the sub-system must be developed and operationalized.

The nerve center is called the Technology Education Committee. It must include enough members to serve as representatives for curriculum determinants and Technology Education. Their role is to ensure that the sub-system output (curriculum) adequately reflects input. Two basic functions are served. First, it processes and classifies information, and secondly, it provides for decision-making. Committee composition, as reported in "The Plan for Futuring of Occupational and Practical Arts" (1981) prepared by the Office of Occupational and Continuing Education, New York State Department of Education, included:

<table>
<thead>
<tr>
<th>Areas</th>
<th>Number of Representatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Industry</td>
<td>5</td>
</tr>
<tr>
<td>School Board(s)</td>
<td>1</td>
</tr>
<tr>
<td>Social Scientist</td>
<td>1</td>
</tr>
<tr>
<td>Guidance</td>
<td>1</td>
</tr>
<tr>
<td>Occupational, Industrial, or Vocational Director Administrators (principals, supervisors, etc.)</td>
<td>3</td>
</tr>
<tr>
<td>2-year College</td>
<td>1</td>
</tr>
<tr>
<td>Technology Education classroom teachers (1 elementary, 1 middle school, and 2 high school)</td>
<td>4</td>
</tr>
<tr>
<td>Technology Education</td>
<td>2</td>
</tr>
<tr>
<td>Teacher Educators</td>
<td>1</td>
</tr>
<tr>
<td>High School Student</td>
<td>1 (non-voting)</td>
</tr>
<tr>
<td>Committee Administrator</td>
<td>1 (non-voting)</td>
</tr>
<tr>
<td>Executive Secretary</td>
<td>1 (non-voting)</td>
</tr>
<tr>
<td>State Education Department</td>
<td>1 (non-voting)</td>
</tr>
</tbody>
</table>

23 Total
The most significant objective in establishing a Committee is to achieve proportional representation. Non-education should be allowed to strongly influence, if not control, the decision-making process. Examples of other committee configurations are as follows:

**Small School District (enrollments ranging from 150-2,000 students)**

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of Representatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Industry</td>
<td>2 or 3</td>
</tr>
<tr>
<td>School Board</td>
<td>1</td>
</tr>
<tr>
<td>Administrator* (Central Office or Building Level)</td>
<td>1</td>
</tr>
<tr>
<td>Technology Education teacher</td>
<td>1</td>
</tr>
<tr>
<td>Rotating Position for Guidance Student, College, etc.</td>
<td>1</td>
</tr>
<tr>
<td>Representatives on a needs basis</td>
<td>6 or 7 Total</td>
</tr>
</tbody>
</table>

*The Administrator may also serve as the Committee Administrator.

**Medium Size School System (enrollments ranging from 2,000-5,000)**

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of Representatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Industry</td>
<td>3 or 4</td>
</tr>
<tr>
<td>School Board</td>
<td>1</td>
</tr>
<tr>
<td>Guidance</td>
<td>1</td>
</tr>
<tr>
<td>Building Principal</td>
<td>1</td>
</tr>
<tr>
<td>Technology Education Teachers (2 middle school, 1 high school)</td>
<td>3</td>
</tr>
<tr>
<td>High School Student</td>
<td>1</td>
</tr>
<tr>
<td>Rotating Position for College, Vocational, and other representatives on a needs basis</td>
<td>1</td>
</tr>
<tr>
<td>Central Office Committee Administrator</td>
<td>1 (non-voting)</td>
</tr>
<tr>
<td></td>
<td>12 or 13 Total</td>
</tr>
</tbody>
</table>
Large School System (enrollment ranging from 5,000 and up)

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of Representatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Industry</td>
<td>5</td>
</tr>
<tr>
<td>School Board</td>
<td>1</td>
</tr>
<tr>
<td>Social Scientist</td>
<td>1</td>
</tr>
<tr>
<td>Guidance</td>
<td>1</td>
</tr>
<tr>
<td>Vocational Director</td>
<td>1</td>
</tr>
<tr>
<td>Building Principal (middle or high school)</td>
<td>1</td>
</tr>
<tr>
<td>College Faculty/Administrator</td>
<td>1</td>
</tr>
<tr>
<td>Technology Education (1 elementary, 1 middle, 2 high school)</td>
<td>4</td>
</tr>
<tr>
<td>Technology Education</td>
<td>1</td>
</tr>
<tr>
<td>Teacher Educator</td>
<td>1</td>
</tr>
<tr>
<td>High School Student</td>
<td>1</td>
</tr>
<tr>
<td>Central Office</td>
<td>1 (non-voting)</td>
</tr>
<tr>
<td>Committee Administrator</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>18 Total</td>
</tr>
</tbody>
</table>

Once the Committee is established, its administrator leads the membership into a comprehensive inservice program. This can be accomplished through a program of carefully selected speakers and authors. Futurists, high technologists, demographic data analysts, economists, and social scientists should be involved. Some school systems may afford live, on-site presentations while others conduct a review of the literature. Still others may use video and audio tape recordings as a means of obtaining a more personalized presentation. Whichever approach is used, it is very important that the entire committee be inserviced together (as a unit) with the most current and reliable information.

Additional inservice will also be necessary for all Committee members on how decisions are made. Several techniques may be used such as trend extrapolation, delphi, future wheels, cross-impact analysis, apollo, and others. After careful study of available data relating to pertinent issues, each committee member must assist in selecting appropriate methods for resolution of issues and demonstrate skill in using each method.
Sub-System Input

Comprehensive, non-restrictive input is essential for sub-system goal achievement. Jackson's Mill Industrial Arts Curriculum Theory (1981) suggests at least six classes of input need to be considered: people; knowledge; material; energy; capital; and finance. A general explanation of each class is provided. These classes serve to minimize areas of omission and maximize the balance of input.

In addition to structured input, this system must also be open to other sources such as guest speakers, authors, special task forces, evaluation, and verification teams, all recognized leaders in the field of Technology Education.

Sub-System Process

The second major element of a Curriculum Development Sub-System is "process." This is a technical means of the system. All input must be analyzed and structured into meaningful groups or categories. Suggested topics and issues for consideration include: mission and goals, population served, content organizers, intended learning outcomes, continuum, modules, subjects and sequences, gaps and overlays, articulation, and guidance. Other methods are possible. This approach is supported by the New York State Futuring Project (1981), Jackson's Mill Industrial Arts Curriculum Theory (1981), and others. Further explanation of the suggested structures is as follows:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission and Goals</td>
<td>To prepare a Mission and Goals statement for Technology Education</td>
</tr>
<tr>
<td>Population Served</td>
<td>To determine student populations technology-based education should serve at the high school level. Students with special needs, varying academic abilities, and divergent interests must be carefully considered. Also, adults interested in re-entering the educational system must be carefully examined.</td>
</tr>
<tr>
<td>Content Organizations</td>
<td>To identify the general areas in which program content can be organized. Examples which use a systems approach are as follows:</td>
</tr>
<tr>
<td></td>
<td>Example 1</td>
</tr>
<tr>
<td></td>
<td>System Resources</td>
</tr>
<tr>
<td></td>
<td>System Process</td>
</tr>
<tr>
<td></td>
<td>System Impacts</td>
</tr>
<tr>
<td></td>
<td>Example 2</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td>Manufacturing</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
</tr>
</tbody>
</table>
Intended Learning Outcomes
To identify what students are supposed to learn as a result of experiences at the high school levels in such areas as knowledge, techniques (skills), and values.

Continuum
To determine the role of a high school level technology education program within an educational continuum extending from kindergarten to adulthood.

Modules, Subjects Sequences
To identify titles for modules and/or subjects, content, time requirements, intended learning outcomes, population served, prerequisites, and prescribed sequences.

Gaps and Overlaps
To identify areas of program content which have been inadvertently overlooked or overlap with other Technology Education courses and programs.

Articulation
To establish an interface between Technology Education and other programs within the local educational agency, area vocational, and technical programs; and postsecondary programs for efficient resource management and coordination of curriculum development.

Guidance
To determine a role for guidance counselors in representing Technology Education programs.

As each task force completes its assignment, a final report should be prepared and submitted to the Technology Education Committee for further action. On occasion the Committee may request additional Task Force attention be given to a specific report. However, generally speaking, after the Committee accepts a report the Task Force has completed its work. This action maximizes the availability of human resources for other tasks.

Task Force reports, after committee review and acceptance, are entered into a verification phase of system process. Here select individuals and small groups considered "experts" within the overall parameters of the sub-system; review each report. This review may well generate additional reports requiring the Committee's attention.

While task forces are completing their work and the verification phase is set in operation, curriculum writing teams must be established and inserviced. It is suggested that all writers be high school Technol-
ogy Education teachers. They will need inservice in understanding the content of all pertinent reports that have been prepared and in curriculum writing skills. A final format must be determined by the Committee's Curriculum Specialist in cooperation with the Committee's Systems Administrator. The combined efforts of the Curriculum Specialist and Systems Administrator are necessary to develop an effective curriculum writing inservice program.

Upon completion of the curriculum writing inservice program, the actual curriculum writing for each module and/or subject begins. This task is somewhat like preparing an interlocking puzzle. Parameters for the overall high school program have been established and a variety of reports providing additional technical detail are available. It is now the task of curriculum writers to process appropriate portions of each report for the use in specific modules and/or subjects in such a way as to efficiently and effectively interface with all other curricula being written. After extensive study and analysis an initial draft of each curriculum is prepared and copies are forwarded to the Technology Education Committee.

**Verification Process**

The final task for the Curriculum Development Sub-System can now be completed. It involves verification of each module and/or subject curriculum. One method of accomplishing this task is to invite a minimum of one representative from each aspect of the project to participate. A verification team might include representatives from the following areas: Technology Education Committee, Mission and Goals, Population Service, Content Organizers, Intended Learning Outcomes, Continuum, Modules, Subjects and Sequences, Gaps and Overlaps, Articulation, Guidance, and Specialists representing the Technology Education profession.

A second method of verification is to select a task force of Committee members. Finally, a third method to consider is establishing a verification process adoption which involves three separate elements as follows: (See Figure 4-3, p. 108)

- **Building Staff**
  Each building's Technology Education staff will assess modules and/or subject curriculum and identify areas for possible revision.

- **Three (3) Experts**
  State and nationally recognized leaders from business, industry, and Technology Education will assess the total high school curriculum and identify areas which may require additional attention.
Local Leaders Representatives from local parent teacher groups, senior citizen groups, civic organizations, teachers' union, business/industry and others will be asked to critique the total curriculum proposal.

**Figure 4-3. This verification process is an adaptation of the New York State Futuring project.**

These are three viable suggestions for establishing a curriculum verification process. Others can be developed. All reports and recommendations from each recognized source are then forwarded to the Committee for further consideration. Curriculum writing teams can then prepare a final draft of their respective modules and/or subjects for input into the Instructional Sub-System.

Sub-System Output. The output of the Curriculum Development Sub-System is what Johnson (1968) describes as a "structured series of..."
intended learning outcomes.” (p. 44) It results in a series of publications. In most instances there will be one publication per module and/or course with each publication describing what should result from instruction.

Sub-System Feedback. Intricately infused into all aspects of the Curriculum Sub-System is a feedback element. This involves both internal and external sources. The integrity of an open system approach should be carefully protected. Issues such as “professional turf” and “tradition” must be recognized and effectively resolved. Feedback, an essential element, serves as a regulatory and/or control function. Without it an open system may be reduced to a closed approach — a move which is strongly discouraged.

**Instructional Program Sub-System**

Curriculum information, as an output of the Curriculum Development Sub-System, serves as input for the Instructional Program Sub-System. It provides guidance for instructional program development. It indicates what is to be learned in specific modules and subject, not how it should be learned. In other words, Johnson's stated position (1968) “... that curriculum has reference to what it is intended that students learn, not what it is intended they do” is appropriate. (p. 44) Curriculum contains a structured series of intended learning outcomes while instruction brings about appropriate actions to produce learning.

The Instructional Program Sub-System gathers its input mainly from curriculum but considers other sources of value (i.e., evaluation, inservicing, financing, instructional strategies, piloting, and implementation). It is a teacher centered sub-system. While the Technology Education Committee still functions, its role is substantially modified. It relinquishes much of its decision-making responsibility to teachers and focuses more on evaluation and feedback activities as related to the overall system Module.

Once again, as in the Curriculum Development Sub-System, comprehensive, non-restrictive input is very important to Instructional Sub-System, goal achievement. Generalists and specialists, in prescribed areas, must continue to be involved in developing and conducting curriculum orientation workshops, developing and implementing a student evaluation program, determining financial implications of new curriculum, developing instructional strategies, piloting new modules and/or subjects, evaluating outcomes of pilot projects and, finally, the full scale implementing of programs on a building, district, county, or state-wide basis.

As information is fed into the sub-system it is analyzed and classified. This may be accomplished in the following phases:
Classification

Phase I
Curriculum Inservice for Instructional Program Sub-System Participants
To provide all participants involved in the Instructional Program Sub-System with an orientation to the curriculum.

Phase II
Financing
To determine the financial needs resulting from implementation of the curriculum. This may include costs for teacher inservice, facility modifications, supplies, equipment, textbooks, etc.

Student Evaluation
To develop a student evaluation system.

Instructional Strategies
To pace and sequence intended learning outcomes as stipulated in the curriculum.
To identify alternative methods of delivery which best accommodate group size, academic ability, media, etc.
To prepare suggested laboratory activities which achieve intended learning outcomes.

Phase III
Teacher Inservice
To provide teacher(s) with appropriate instructional information and skills development activities in order to implement each module and/or course curriculum.

Phase IV
Piloting and Evaluation
To implement an appropriate instructional program for the curriculum.
To determine the instructional program’s degree of effectiveness.

As each phase of process is completed, information enters into the feedback and modification element of the Sub-System. The Committee
reviews all available information so that issues and constraints may be identified and resolved. Decisions are made which may result in some modifications within the Instructional Sub-System. Eventually, as many activities and projects draw to a close, output from the Instructional Program Sub-System permits full scale implementation.

Final products and/or publications of an Open Systems Approach to preparing Technology Education curricula and instructional programs can be presented in a variety of ways. As indicated earlier, the overall process tends to generate an extensive number of reports. Therefore, to encourage maximum utilization of the final results, an extensive synthesis and reorganization of information may be necessary. In other words, though the process is relatively complex, the end products should be reduced to one or more clear, concise, and useable publications.

**SYSTEMS OUTCOMES**

One way of presenting final outcomes of the Curriculum and Instructional Program Development Systems is to organize information under headings of Content, Instruction, Facilities, and Standards and Funding. Content is subdivided into knowledge, skills, and values unique to the total program as well as for specific modules, courses, and sequences. The instruction section contains information about development, delivery, and activities. Facilities address renovation needs which may be necessary. The section concerning Standards and Funding provides insight for directions to seek assistance to assess and finance Technology Education programs.

**Content**

To establish a sound content base for high school Technology Education will require synthesizing an abundant amount of industrial arts subject matter, as well as developing new course material which will reflect the technical and social-cultural aspects of modern technology. This instructional material can be collected and properly organized in a content reservoir. As shown in Figure 4-4, the reservoir has four divisions (communication, construction, manufacturing, and transportation) with a center area that includes elements of technology that are mutual to all four divisions. Each element is significant to the entire information pool to provide interaction among the reservoir divisions. High school Technology Education instructors can build and replenish this content reservoir with accurate, up-to-date subject matter by utilizing resources such as government agencies, local business/industries, multinational corporations, student input, documented publications, etc. The dimension of the reservoir should include substantial information to sup-
port the purpose and objectives of a given school program. In essence, high school technology content focuses on instructional materials that will further develop students' knowledge, skills, and values for life in a technological world.

Figure 4-4. Content for technology education programs is inclusive of the entire technical and social cultural realm. New content for the technology education curriculum can be acquired from a variety of educational resources. This information formulates a reservoir of new knowledge significant to the technical adaptive systems and the elements of technology.
Daily living provides people with a degree of technological awareness. This perception is largely influenced by the media and self-experiences individuals encounter in their particular lifestyles. People commonly perceive that new technology is developed to improve the quality of life standards and unexpectedly creates problems. Consequently, people observe technical failures and social-cultural disruptions. New technology is developed to solve these problems which makes the future possible ("Here’s How . . .,") 1981). What formal education do high school students need to be knowledgeable of technology?

As teachers of young adults, Technology Educators can help students to be knowledgeable of technology’s evolution, utilization, and significance in our society (Maley, 1981, p. 5). The students’ realization can be developed through a step-by-step approach utilizing subject matter from the entire content reservoir. Beginning with simple content materials and advancing toward the more complex phenomenon, Technology Education programs contract a degree of technological literacy within students. This education process may take place by having students:

- Define what technology is
- Use low, intermediate, and high forms of technology
- Assess the technical and social-cultural changes of new technology
- Select appropriate technology for local and global usage
- Forecast the technology necessary for the future.

The learned outcomes of these actions should indicate that students realize:

1. The need exists to be knowledgeable of new technical developments, social-cultural issues, and occupational frontiers that exist as a result of technological growth.
2. The American public is highly dependent on modern technology to function as a society.
3. High school students are an important human resource that will develop new technology for the future.

Such a social/technical awareness provides students with an adequate knowledge base to understand technology in its higher form. The students’ level of knowledge encompasses a broader vocabulary of terms which relate to new innovations, as well as an understanding of the hardware applications. This knowledge base is the means in which high school graduates can be contributing citizens to their culture. The social/technical awareness is the students’ foundation of learning how to learn and adapting to change.
Changes which are occurring throughout the world as a result of the technology explosion are reshaping the lifestyle of the American populous. Forecasts indicate this revolution will continue to have greater effects on people between now and the year 2000 ("Here's How . . .", 1981). To absorb the technological shock, high school graduates need to be provided with the necessary survival skills to become technically competent and socially proficient.

Re-industrialization has placed greater emphasis on the use of high technology for producing goods and providing services. High school industrial arts programs have been mainly concerned with technical skill development of low and intermediate forms of technology. Some of the traditional instructional content is still vitally important to provide students with a conceptual understanding of the basic processes which occur in communication, construction, manufacturing, and transportation. This content should be properly categorized in the content reservoir depicted in Figure 4-4.

Up-to-date educational materials which emphasize the technical and social-cultural aspects of technology likewise need to be gathered and made a part of the instructional content. Each area of the content reservoir needs to be arranged so the content for skill development relates to low, intermediate or high technology. These levels are vitally important for the high school curriculum to promote the development of students' cognitive and psychomotor abilities. The skills may best be established by beginning with instructional content at a simple level and moving toward more complex subject matter. Students should attain a competency level of the very basic hand tool processes, as well as comprehend the most sophisticated cybernetic controls.

The technical skill area focuses upon students' ability to correctly use modern tools, machines, materials, processes, and technical information. Social-cultural skill development involves helping students to become more capable of decision-making, problem-solving, communicating, and coping as citizens, consumers, or employees in a changing world. A more detailed explanation of the subject matter for skill development is presented in Figure 4-5 (p. 115). The level of skill that students attain from their technical and social-cultural learning experiences reflects their technical and technological literacy.

During high school, students encounter learning experiences which formulate the basis of their adult values. As young adults, they need proper guidance from parents and teachers to establish a sound value system. Technology Education content can contribute significantly in the value clarification process by expanding the affective domain of high school students.

Subject matter that focuses on value clarification involves students' action in making value judgements and value choices pertaining to people
Figure 4-5. Technical and social cultural skills may best be established by beginning with instructional content at a simple level and moving toward more complex subject matter. Students acquire technical and technological literacy during skill development learning activities.
and their use of technology (Peter & Peter, 1978, p. 29). These decision-making tasks of valuing include a relation of the human element in the content reservoir with other elements of technology and the mutual reservoir divisions (Figure 4-4). This learning experience would provide students with the opportunity to analyze people's use of technical systems and the social consequences that have resulted.

The value judgements and choices students pronounce may help them place assessment on their selection of the most appropriate form of communication, construction, manufacturing, and transportation technology. This value orientation helps students establish a social consciousness of their accessibility to new innovations. Because technology changes so rapidly, individuals need to make value judgements and choices that directly affect their lifestyle. It is important that high school students possess the ability to clarify their value system to prevent complications of the psychological and physiological dimensions.

Learning experiences derived from Technology Education content may contribute to developing a value system that includes:

- Values for relationships with people
- Values for maintaining the environment
- Values for work roles
- Values for continuing education
- Values for appreciation of creativity (art, literature, invention, etc.)
- Values for worthy use of leisure time.

This value system helps students make mature decisions regarding the interrelationship of social, technological, and ecological systems. Students possessing such a set of values will be capable of contributing to the improvement of quality of life standards. Most importantly, students would learn a great deal about themselves and others. These learning outcomes may help them be better prepared for graduation from high school and to select a pursuit in life.

**Exemplary Technology Education Programs**

The 1980's revealed attempts by practitioners at the high school level to develop Technology Education programs. Instructors who have taken on the role of program developers have indicated success in implementing high school models.

A special Technology Education issue of *School Shop Magazine* (1980) featured the exemplary programs at Triad High School in Illinois and Wild Rose High School in Wisconsin. (pp. 40 & 42) These programs indicated several similarities that are significant for instructors to con-
sider in conducting a program transition. The Triad and Wild Rose models indicated that a cluster approach was used to group traditional industrial arts content areas for instruction of the universal technical systems. Both programs also included a degree of industrial arts subject matter, such as woodworking and metalworking. The goals of each program centered on providing students with knowledge to be intelligent participants in our technological society. The Triad and Wild Rose curricula may best be identified as exemplary programs. The efforts of these high schools are examples of what can be considered a goal for other practitioners to accomplish in the near future. However, revisions will need to be made in both programs within the next decade to provide students with a comprehensive technology education.

Currently there are other exemplary high school curricula that exist in West Virginia county school districts. These programs are a result of a cooperative effort between the West Virginia University Technology Education Program and county schools. One program that has been presented several times at the International Technology Education Association (ITEA) Conference is Project Open in Wetzel County. This program provides an introduction to technology at the ninth grade with grades ten through twelve offering one year of study in production, transportation, and communication. Students study each technical area and the social-cultural implications through laboratory and community experiences (Peterson, 1978, p. 11). Figure 4-6 (p. 118) illustrates an overview of a program transition from industrial arts to Technology Education.

The course of study high school personnel develop to pursue Technology Education will need to be flexible and capable of adapting to changing technology. DeVore’s report, Structure and Content Foundation for Curriculum Development (1968) and Bensen’s article, Trends in Program Structure for Technology Education (1981), provide supportive research to consider in developing a four-level sequential model. Sequential models tend to be planned from simple to complex tasks. A sequential model high school instructors could adopt would include:

1. An awareness level — to introduce students to the study of technology. Students would become aware of the technical and social-cultural aspects of technology.

2. A skill development — to further advance students’ technical and social-cultural skills in the areas of communication technology, material and process technology, and transportation technology. Students would acquire technical competencies to use tools, machines, materials, etc. safely in each area of study. They would gain social-cultural proficiency through group learning experiences in each subject.
### A PROGRAM TRANSITION

<table>
<thead>
<tr>
<th>INDUSTRIAL ARTS</th>
<th>TECHNOLOGY EDUCATION</th>
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<tbody>
<tr>
<td><strong>RATIONALE</strong></td>
<td><strong>RATIONALE</strong></td>
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<td>STUDY OF TECHNOLOGY FOR A POST-INDUSTRIAL SOCIETY</td>
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<table>
<thead>
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<th>OBJECTIVE</th>
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<td>INTERPRETATION OF INDUSTRY ARTS &amp; CRAFTS SKILLS PRE-VOCATIONAL SKILLS</td>
<td>TECHNOLOGICAL LITERACY TECHNICAL-SOCIAL-CULTURAL SKILLS</td>
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<th>STRUCTURE</th>
<th>STRUCTURE</th>
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<td>DRAWING WOODWORKING METALWORKING ELECTRICITY</td>
<td>TECHNICAL ADAPTIVE SYSTEMS (COMMUNICATION–CONSTRUCTION–MANUFACTURING–TRANSPORTATION)</td>
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<table>
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<th>CONTENT</th>
<th>CONTENT</th>
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<tr>
<td>MATERIAL-BASED</td>
<td>TECHNOLOGY</td>
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**Figure 4-6.** A transition from Industrial Arts to Technology Education will require restating program rationale, objectives, structure, and content. Classroom instructors are the key people to lead this program transition.
3. **A realization level** — to provide students with a perception of various communication systems, construction systems, manufacturing systems, and transportation systems. Students would visualize the technical/social relationship between people and their use of technology.

4. **An investigation level** — to provide students with the opportunity to obtain advance study in specific areas of communication, construction, manufacturing, and transportation technology. Students would become involved in research and experimentation, design and development, and future studies in areas such as robotics, fiber optics, automation, lasers, etc.

The course structure of this sequential model is depicted in Figure 4-7 (p. 120). Each level of the model is designed for a one year period. Schools of all sizes could utilize it by scheduling classes according to student/teacher ratios. The length of time provided for instruction in upper level courses in small and mid-size school programs would probably be less than larger school programs because of fewer staff members. A course offering schedule that relates the course level and title of the school size by semester length is illustrated in Figure 4-8 (p. 121).

The instructional design teachers utilize will influence the learning outcomes of sequential models. Proper instruction is an equally important topic for high school instructors to consider.

**Instruction**

The instruction that high school personnel prepare for classroom application is the major determinant whether or not students learn about technology. Instruction needs to be technological in nature if students are to understand the technical and social-cultural aspects. Teachers will need to place assessment on their current instructional practices to determine the usefulness of their present approach of subject matter delivery. They will likewise need to examine additional means of instruction to incorporate technology content into their classrooms. Most importantly, the development of quality instruction for Technology Education will be determined by the creativity and pursuit of the teacher who wants to teach young adults about technology. Instruction theorists Gagne and Briggs, (1974), have strongly reinforced the concept that: “Learning must be planned, rather than haphazard, so that each person will come closer to the goals of optimal use of his talents, enjoyment of life, and integration with his physical and social environment.” (p. 4)
Figure 4-7. Technology education programs can be structured so that courses are in sequential order. This organization of subject matter helps facilitate students' learning from simple to complex tasks. The course titles are representative of the technical systems, not a particular material or skill area of study. The arrows indicate flexibility that allows students to enroll in courses and in more than one area of interest.
<table>
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<tr>
<th>COURSE SCHEDULE BY SEMESTER(S)</th>
<th>SEMESTERS RELATING TO SCHOOL SIZE</th>
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<tbody>
<tr>
<td></td>
<td>SMALL</td>
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<tr>
<td>INVESTIGATION LEVEL</td>
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<tr>
<td>ADVANCED COMMUNICATION TECHNOLOGY</td>
<td>$\frac{1}{2}$</td>
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<tr>
<td>ADVANCED CONSTRUCTION TECHNOLOGY</td>
<td>$\frac{1}{2}$</td>
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<tr>
<td>ADVANCED MANUFACTURING TECHNOLOGY</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>ADVANCED TRANSPORTATION TECHNOLOGY</td>
<td>$\frac{1}{2}$</td>
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<tr>
<td>REALIZATION LEVEL</td>
<td></td>
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<tr>
<td>COMMUNICATION SYSTEMS</td>
<td>$\frac{1}{2}$</td>
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<tr>
<td>CONSTRUCTION SYSTEMS</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>MANUFACTURING SYSTEMS</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>TRANSPORTATION SYSTEMS</td>
<td>$\frac{1}{2}$</td>
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<tr>
<td>SKILL DEVELOPMENT LEVEL</td>
<td></td>
</tr>
<tr>
<td>COMMUNICATION TECHNOLOGY</td>
<td>$\frac{1}{2}$</td>
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<tr>
<td>MATERIAL AND PROCESS TECHNOLOGY</td>
<td>1</td>
</tr>
<tr>
<td>TRANSPORTATION TECHNOLOGY</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>AWARENESS LEVEL</td>
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<tr>
<td>INTRODUCTION TO TECHNOLOGY</td>
<td>2</td>
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</table>

Figure 4-8. Small, mid-size, and large high schools can utilize sequential technology education models. Scheduling of courses is the critical factor for all high schools to consider. This course schedule is designed to provide courses on a semester basis.
Technology Education instruction should be:

- designed to reflect the program rationale
- developed on basis of the program objectives
- assessed for appropriateness prior to classroom application
- executed as a teaching method to deliver course content to students
- evaluated for meaningfulness for the students' learning
- redesigned to include new technical and social-cultural innovations that are the state of the art.

Classroom practitioners can provide and maintain instructional materials through utilizing accessible resources available to high school educators. The resources cited in Figure 4-4 are key resources for teachers to consider in their instructional procedure.

*Instructional Development.* The process of developing instructional materials for Technology Education involves organizing ideas, suggestions, or research that pertains to communication, construction, manufacturing, and transportation. This task is the initial step to create lesson plans for dissemination in the classroom. Although the school facility and the environment of the school district may affect the nature of learning in each high school somewhat differently, the teacher is responsible to make accurate simulations to the real world to provide students with beneficial instructional units.

Teachers that develop instruction for Technology Education subjects may begin by analyzing the universal technical systems model in the Jackson's Mill Curriculum Theory. This model inclusively proves the inputs, processes, and outputs of communication, construction, manufacturing, and transportation systems. From the model, instructors identify instructional content present in contemporary literature, instructional aids, and educational resources for developing classroom lessons and assignments.

Since industrial arts has always been highly concerned with hands-on and minds-on learning, teachers will naturally continue these instructional goals in Technology Education programs. In developing learning activity units, instructors may consider building projects, constructing scale models, discussing technology, experimenting, gaming, presenting, reading, researching, role playing, simulating, visualizing, and writing as possible instructional strategies. An overview of the technical and social-cultural development these strategies initiate for students, and a brief description of how to apply each approach may be analyzed in the following:
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Objective</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>Building Projects</td>
<td>Develops students’ cognitive, psychomotor, and affective skills</td>
<td>Use modern tools, materials, processes and component parts</td>
</tr>
<tr>
<td>Constructing Scale Models</td>
<td>Develops students’ understanding of past, present, and future technology</td>
<td>Use low cost materials to construct working models that depict technical functions of tool, machine, and control developments</td>
</tr>
<tr>
<td>Discussing Technology</td>
<td>Develops students’ awareness of new technology and issues</td>
<td>Use formal and informal conversations; hold special technology discussions to reveal students’ knowledge of technology</td>
</tr>
<tr>
<td>Experimenting</td>
<td>Develops students’ ability to understand the process which is critical in developing new technology</td>
<td>Use laboratory activities which involve discovery or inquiry tasks</td>
</tr>
<tr>
<td>Gaming</td>
<td>Develops students’ interest to learn about technology</td>
<td>Use question-answer and game-board approaches to motivate students in learning about foreign cultures and other aspects of technology and the real world</td>
</tr>
<tr>
<td>Presenting</td>
<td>Develops students’ vocabulary to include new technological terms and express their intelligence</td>
<td>Use class presentations as a form of student information sharing</td>
</tr>
<tr>
<td>Strategy</td>
<td>Objective</td>
<td>Application</td>
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<tr>
<td>Reading</td>
<td>Develops students’ ability to comprehend technology subject matter</td>
<td>Use books, magazines, newspapers, and related technology literature to create a technology book-shelf and bulletin board</td>
</tr>
<tr>
<td>Researching</td>
<td>Develops students’ understanding of new tools, materials, processes, and social-cultural problems</td>
<td>Use investigating tasks that involve technical and social-cultural endeavors</td>
</tr>
<tr>
<td>Role-Playing</td>
<td>Develops students’ understanding concerning people and their use of technology around the world in business/industry or everyday life</td>
<td>Use classroom settings to illustrate different roles people assume in the world</td>
</tr>
<tr>
<td>Simulating</td>
<td>Develops students’ realization of communication, construction, manufacturing, and transportation systems</td>
<td>Use activities to create learning environments which may reflect high technology industries, rapid transit systems, etc.</td>
</tr>
<tr>
<td>Visualizing</td>
<td>Develops students’ understanding of the abstract aspects of technology; also provides broad view of technology in general</td>
<td>Use audiovisual aids as films, slides, movies, etc.</td>
</tr>
<tr>
<td>Writing</td>
<td>Develops students’ thinking of technology in the past, present, and future</td>
<td>Use assigned technical reports, scenarios, and forecasts.</td>
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</table>
Instructional development for Technology Education is a continuous process that attempts to keep abreast with rapid changes occurring during the information revolution. A large part of preparing instruction involves identifying new developments in communication, construction, manufacturing, and transportation technology and then selecting appropriate strategies to incorporate content into the classroom. Teachers should realize that one or more strategies previously mentioned may be applied during a particular activity.

Instructional Delivery. Classroom instruction may be delivered through teacher-to-student, student-to-student, or machine-to-student relations. Although the teacher will not necessarily be the center of the classroom, they will remain the class manager. Previti (1977) described the teacher in this role to be a teacher-manager responsible for the planning, controlling, leading, and organizing the classroom. (p. 8) Each means of instruction helps provide students with broad-based technology experiences significant at the high school.

The teacher-to-student relation is a transitional method industrial arts instructors have used exclusively in their teaching. This lecture-demonstration-project approach provides clear explanations for technical procedures, however, this approach does not completely explain the social-cultural dimension or technological impact perspective that is equally important in technology education.

Allowing student-to-student instruction to also be part of technology education helps increase comprehension for students. In instances where students are working together, their explanations are reinforcing and help facilitate learning of complex material. Student-to-student learning is one approach to bring an abundance of technology information into the classroom. Sharing of terms, ideas, and new technical developments is one of the best developers of technological literacy.

Student-to-machine instruction also contributes valuable learning experiences in technology education. Students that have the opportunity to review assignments or demonstrations at VCR carousels can clarify instruction they missed during regular class time. Computer-assisted instruction (CAI) offers another option for instructors to utilize. CAI is an excellent method to deal with special needs students who progress at various learning rates.

The degree to which instructors understand how to organize instructional materials is significant to the success of lessons presented in technology education courses. To provide a clearer understanding of the instructional process for technology education, an analysis needs to be made of activities.

Instructional Activities. Technology activities provide a meaningful dimension to high school students’ education. The opportunity to actively participate in communication, construction, manufacturing, and transportation activities increases students’ motivation to learn. In some learning situations, technology education facilities become the place
to decision-make and problem-solve technical and social-cultural issues. Other activities may be directed to students' creativity to reproduce or develop simulated models of new technology. Some technology topics reveal broad connotations that provide a base to conduct multidisciplinary activities in the high school. Such topics as aerodynamics, computerization, re-industrialization, space exploration, etc. are examples teachers may consider. Multidisciplinary activities are a significant part of technology education because interaction between disciplines provides culminating educational experiences for students. Since a portion of graduates will never further their formal education, such activities will enhance their understanding of science, mathematics, and literary principles to improve the quality of today's public education.

To further clarify the makeup of technology activities, explanations are provided in the following examples of communication, construction, manufacturing, transportation, and multidisciplinary activities. Each sample activity indicates the course, instructional unit, list of objectives, activity description, and materials needed to conduct the activity.

**COMMUNICATION ACTIVITY**

**Course:** Introduction to Technology

**Instructional Unit:** People communicate by using electrical signals. (one week)

**Objectives:**

1. Explain the significance of electrical signals in our society.
2. Develop students' technical skills in using electrical hand tools and test equipment.
3. Illustrate students' creativity in the design of the communication system.
4. Enhance students' ability to write in technical terms.
5. Allow students to verbally express their ideas in a formal manner.

**Activity Description:** This activity will involve students constructing a working model of an electrical communication system. In groups of two, students design a system that will communicate through sound or signal lights on a twelve by twelve inch piece of pressboard. Students will receive all component parts and materials from the instructor. In addition to constructing the model, each group will write a one to two page explanation of their model. The completion of this activity will involve each group presenting their model to the class.
Materials needed for this activity are as follows: 12" x 12" pressboard, 9 volt batteries, small speakers, variable potentiometers, 9 volt light sockets, 9 volt light bulbs, microswitches, and single strand electrical wire.

CONSTRUCTION ACTIVITY

Course: Constructions Systems
Instructional Unit: Solar systems applicable for residential dwellings. (twelve weeks)

Objectives:
1. Involve students' learning about solar systems that can be applied to present residential homes.
2. Teach students to safely use construction tools and processes involved in home construction.
3. Provide students with the opportunity to research, develop, and construct a solar heating system.
4. Broaden students' vocabulary to include energy-related terms.
5. Increase students' consumer awareness concerning the cost of home heating and cooling.

Activity Description: The construction of a small mobile solar hut will involve organizing groups of students to research, experiment, and construct the building. Part I of the project focuses upon the framework and general construction of the hut. Part II involves the research, experimentation, and building of a solar greenhouse, hot water system, and general solar adaptations (insulations, exterior finishes, caulking, etc.). Each group will include in their research illustrative examples of solar systems that presently exist in residential areas. Information concerning the amount of energy conservation such systems provide should be included as part of the research. Students will mount their examples in a logical manner on a poster board. Posters will be placed in the construction area of the lab to be shared with other students. Groups will apply their research and experiments to construct and attach the solar systems to the hut.

Materials needed for the solar hut are as follows: hut construction — 2 x 6's, 2 x 4's, 1 x 6's, 1/2" x 4' x 8' sheets of plywood, nails (common, finish and roofing) asphalt shingles, white exterior paint, solid core door, door hardware, window glass, insulation, interior paneling, and floor covering. Greenhouse construction — 1 x 4's, 2 x 4's, 1/8" plexiglass or window glass, foam rubber insulating strips, silicon caulking, and flat black enamel paint. Hot water system — 2 x 4's, 1 x 4's, 1/4"
plywood (collector frame), 1/2" copper pipe, copper elbows, 28 gauge sheet metal, aluminum cans, pop rivets, (absorber panel), 1/8" plexiglass sheet or window glass collector, glazing, silicon caulking, flat black enamel paint, used water heater, and small water pump. (The actual amount of materials needed will be determined by the size of hut.)

**MANUFACTURING ACTIVITY**

Course: Manufacturing Systems  
Instructional Unit: Packaging is an important phase of a manufacturing system. (one week)

Objectives:

1. Illustrate to students the importance of packaging products for distribution to consumers.
2. Provide an explanation of the type of materials used in packaging products.
3. Develop an awareness of the significance of packaging a product for protection, advertisement, and handling or storing.
4. Teach students the proper techniques to package various types of items (breakables, consumables, sharp edge items, etc.)

Activity Description: Students will individually design a package for a given product. The instructor may wish to have students design a package for the product the class manufactured. An alternative is to have students design a package for a product they selected from a list of suggested ideas. Some ideas are a ceramic dish, food, egg, pen, pencil, metal scriber, etc. The student-designed package should protect, advertise, and increase the handling of the product. During the process of designing, students should note where they saw this packaging technique applied. At the completion of the assignment, students need to design a test to check their packages. The activity will be finalized as students share their packaging ideas.

Materials commonly used in packaging are as follows: cardboard, newspaper, packaging tape, styrofoam "peanuts", styrofoam sheets, plastic bags, plastic wrap, wrapping paper, string, and hot glue. (Teachers may find it beneficial to save packaging materials from supply shipments to conduct this activity.)
TRANSPORTATION ACTIVITY

Course: Advanced Transportation Technology

Instructional Unit: Alternative power sources that can be used for personal transportation systems. (three weeks)

Objectives:

1. Introduce students to alternative sources of power for transporting people.
2. Illustrate to students how alternative power sources work.
3. Provide an advanced engineering-design problem that concerns aerodynamics styling and moveable parts.
4. Expand students' thinking about the design of future vehicles and the acceptance of such personal transportation systems by society.

Activity Description: Students work in pairs to design and construct a working model of a personal transportation system that will be powered by a new technology energy source. Two common sources of power that may be used in this activity are solar photovoltaic cells and self-propelled systems. Each group will begin with a thumbnail sketch of their transportation system. Design groups will need to consider wind resistance, traction, mobility, personal comfort, and appearance. When the designs are completed, each should illustrate the general outline of the vehicle and power train. Construction of the transportation model will entail students using a variety of wood, metal, plastic, and ceramic materials to make the necessary component parts. The power source may be built or purchased by the student. To finalize this activity, all vehicles will need to be tested according to their performance and appearance. A discussion session should be conducted to allow students to express their thoughts about society using vehicles that may look and run entirely different than what is present today.

Materials needed for this activity are as follows: balsa or pine wood, 1/4" dowel rods, 1/8" metal rods, 28 gauge sheet metal, rubber bands, plexiglass, plastic wheels, and various colors of paint.

MULTIDISCIPLINARY ACTIVITY

Courses: Manufacturing Systems, Advanced Algebra, and Data Processing

Instructional Unit: Analyzing productivity in a manufacturing system with the aid of a computer.
Objectives:

1. Demonstrate how students' high school education relates to real industrial and business applications.
2. Provide interaction among disciplines in the school to provide a meaningful education for students.
3. Further students' knowledge of modern technology, such as the computer.
4. Illustrate the changes new technology has proposed in industrial production.

Activity Description: Three classes will be involved in this activity to analyze the productivity of a student-designed manufacturing system with the aid of a personal computer. Commonly, manufacturing classes conduct simple time and motion studies by using stop watches and clip boards to record the efficiency of the manufacturing system. The feedback from this information allows students to make adjustments in their system to speed up production. In this activity, the recorded material on the clip board is going to be processed through a computer in a data processing lab, rather than by manufacturing students' calculations. The activity should begin with a joint meeting of the classes or class representatives. During the meeting, production managers will have to explain the need to analyze the production flow to the algebra and data processing students. Step two of this activity will involve the algebra class writing algebraic formulas for the data processing class to include in a computer program. Data processing students store the program on a flexible diskette to be ready for daily input from the manufacturing systems class. Each day the manufacturing system runs, time and motion engineers report their data to the data processing lab. In return, they receive a printout to analyze for making revisions in the production flow. At the end of the manufacturing run, computer printouts may be divided among the classes for individual use. The manufacturing systems class may wish to save the data diskette for future manufacturing classes.

Materials needed for this activity are as follows: flexible disk and printer paper.

Technology-based activities are very much open for teacher creativity. After reading the activities, classroom teachers may have ideas to include as activities when they introduce units in their classes. Teachers also observe that technology education activities may be designed quite simple for introductory classes, or very complex for advanced courses. Naturally, certain modifications and restrictions may need to be made by some high schools when selecting and designing activities because of facility and funding limitations. These two factors are of equal importance to instruction and likewise need to be further addressed.
Implementation of a technology education high school curriculum may require some modification of laboratory facilities. In smaller buildings where general laboratories are being used, needed change may be minimal. However, in medium and large high school buildings where unit laboratories such as woodworking, electricity/electronics, plastics, ceramics, power mechanics and automotive, metalworking, graphic arts, mechanical drawing, and others are used, the issue of facility renovation becomes much more challenging. Regardless of the size of the building, implementation of a technology education curriculum will require some degree of facility modification.

Factors requiring careful consideration when planning changes in lab facilities include:

- a technology education curriculum
- current and projected enrollments, class size
- compliance with local, state, and federal regulations
- delivery system to be used (team teaching, individualized)
- student activities
- method of renovating facilities
- relocating existing furniture, tools, and equipment
- procuring additional equipment and funding
- and many others.

The transition from traditional unit approaches and/or unit labs to facilities which best support a communication, manufacturing, construction, and transportation technology-based curriculum will require skillful management.

To initiate some preliminary thoughts about facility renovation and/or reorganization the following statements, regarding new program segment needs, should be considered:

- Communication — will require equipment and furniture usually found in mechanical drawing, graphic arts, and electricity/electronic labs.
- Manufacturing — will require equipment and furniture usually found in woodworking, metalworking, ceramics and plastics labs.
- Construction — will require equipment and furniture also found in woodworking, metalworking, ceramics and plastic labs. Additionally some electrical tools and equipment will be needed.
- Transportation — will require equipment and furniture usually found in power mechanics, small engines, automotive, wood-
working, metalworking, plastics, ceramics and electricity/electronics labs.

These combinations require initial consideration as technology education program facilities are being designed.

As combinations of existing furniture and equipment are being considered for relocation, a list of additional needs must be compiled which insure a program transition into areas such as:

... molecular biology; genetic engineering (cloning); nuclear power (fission and fusion) and solar electric (space power); habitation underground, ocean-bottom, arctic and space; widebody jet and space shuttle; radar, lasers, television, satellite communications; electronic data processing, computer storage and feedback control; systems analysis and design, large-scale project management and deliberate invention. (Von Puttkamer, 1983, p. 5)

These are new and advancing technologies that today’s students will need to understand in preparing for their tomorrow. Modern technology education facilities must be provided to assure students appropriate laboratory experiences in these areas.

There is an additional guide in planning technology education facilities called FAM. An acronym, FAM represents flexibility, adaptability and mobility. These are three important concepts worthy of considerable attention when designing modern facilities.

FAM, as one might readily conclude is not intended to provide specific and exact steps for conducting a facility renovation. It simply provides a very general framework within which some initial study and investigation can be undertaken. There are too many recognized variables between and among high school buildings to go into further detail.

**Flexibility**

Facilities should be designed using a systems, sub-systems and modular approach. Some of the characteristics of this approach are:

- cluster individual and/or small groups of machines with common utility and environmental control requirements.
- standardized electrical outlets and equipment connectors, exhaust system inlets and outlets, compressed air couplings, vacuum system connectors, liquid (water) connectors, machine chucks and keys and taper fits.
- overhead electrical bus bars and drop reels should be considered over floor mounted outlets.
- modular designed tool boards and display units.
- small machines designed with lower center of gravity.
• external computer control of machine processes. Some machines provide internal (NC) control. This restricts the use of a computer to only one machine.
• utility towers providing air, electrical, vacuums and water which can be plugged into several locations in each lab.
• machines that cut or form a variety of materials opposed to just one or two with a prescribed degree of accuracy.
• openings between labs which will allow machines, furniture, students and teachers unrestricted movement between labs.

Adaptability

Between any two periods of a school day a laboratory may have to be converted from communication to manufacturing, transportation to construction, dark room to finishing room, or many other combinations. To accomplish this, a highly effective environmental control system must be installed. It must be capable of controlling sound, light, dust, odors, fumes (both lighter and heavier than air), humidity, and temperature. All this is possible with a properly designed environmental control system.

Mobility

Creating an educational environment that least restricts the learning process sometimes requires mobilizing many components within the technology education facilities. Sometimes students need to move while in other instances it is the furniture, tools, equipments, displays, etc, that should be moved or rearranged. Sets of casters for raising and lowering (mechanical and/or hydraulic) may be helpful. This will allow a high degree of mobility in and among the technology education labs.

STANDARDS AND FUNDING

High school technology education instructors can assess their programs by using the Standards for Technology Education Programs. This assessment guide is a revision of the Standards for Industrial Arts Programs developed to provide instructors with a comprehensive document to assess new and developing technology education programs. The Standards for Technology Education Programs are suggested to be used at the time of program implementation, evaluation, and revision.

In addition to using the prepared standards, high school programs may wish to develop an assessment instrument to measure students' development to technological literacy. The terms technological literacy express an important characteristic that describes technology students'
Stashak (1981) expressed a publisher's perspective of technological literacy in the following statements:

By being technologically literate, we believe, students will be able to:

1. Contribute to the advancement of technology.
2. Be better able to assess current and future technology.
3. Be better able to control technology.
4. Be better able to adapt to their changing world. (p. 23)

The terms advancement, assess, control, and adapt are recurring themes that indicate a need to consider technological literacy as a standard for assessing technology education programs. Furthermore, a technological literacy instrument would involve much intense development to measure students' abilities pertaining to the study of technology.

In the event of implementing national standards for Technology Education, funding would appear to be a key issue. Currently industrial arts programs are eligible to receive funds granted under Title II, Part A, of the 1976 Vocational Act (Status of Federal Funding, 1981). The Summary Report for FY80 and 81 vocational funding listed no categorical funding for Technology Education. Instructors at high school level could pursue two routes to continue receiving funds for their school budget.

1. Remain in close alliance with vocational funding regulations and be capable of producing evidence of using reimbursement funding appropriately.
2. Investigate alternative funding sources such as associations, foundations, local and national civic organizations, and government grants for exemplary programs.

The funding of Technology Education may not be delayed for another decade. At the present time, there is some indication of legislative efforts to provide financial support to help establish a most needed area of study in the high school — technology education.

SUMMARY

The needs of high school students in today's society are both vast and complex. High school curricula are expanding in directions to provide both technical skill subject areas and sociology studies. In an era that seems to include much uncertainty as to what direction to expand high school curricula, educators can be safe including Technology Education programs derived from a systematic approach to program
development, a thoroughly developed course of study, and a well-researched instructional design. Graduates from such high schools will receive an appropriate degree to technological literacy to pursue their life in today's technological world.

REFERENCES


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"Here's how technology will affect you!" Mechanix Illustrated, January 1981, pp. 46-47.


At no other time has industrial arts education been in such a position to make a significant impact throughout the educational community of our nation. With increasing regularity, industrial arts educators have been calling for a broad study of industry and technology. In fact, Technology Education is being advocated by educators in fields other than Industrial Arts. In *Teaching the Future*, Draper Kauffman, Jr. (1976) calls for the teaching of technology to prepare students to “anticipate” needs and solutions to such problems as housing, transportation, and energy (p. 9). Burns and Grooks (1978) suggest that schools undergo curriculum reform that emphasizes technology and technical innovations to prepare youth for constant societal changes. Ferkiss (1974) in *The Future of Technological Civilization* urges the study of technology so humans will be able to control rather than be controlled by technology. Because of “massive environmental changes” Pograw (1982) calls for school curricula that are “technologically relevant” (p. 610).

With this in mind, industrial arts educators who set out to develop technologically oriented programs must avoid common curriculum development mistakes. Our control-oriented, teacher directed programs have become obsolete. The information explosion and the increasing pace of change mean that we can never again develop curricula that will be needed by all students. As Coombs (1981) stated “A common content is simply no longer a valid goal for education” (p. 369). Educators in all disciplines will increasingly be unable to identify the knowledge and behaviors that will be demanded by the future.
What will the world be like in the twenty-first century? No one knows for certain because of unbridled technological change. Yet, although technology cannot determine the future without assistance from humans, there is little question that individuals and society are under pressure to conform to the demands of technological efficiency. Because of this, the possibility exists that the essence of humanity will be lost in the process. Will human history come to an end and be converted into a mere prelude to the history of a post-human society in which machines rule? Educators must not allow this to happen. We must rethink our roles as developers of youth. Technology educators, in particular, have much to offer tomorrow’s leaders in developing policies and decisions about technology to serve human purposes.

Preparing students with competencies they will need as individuals and as citizens for a challenging future is no easy task. It will demand dedication and a joint effort by teachers in all disciplines at all levels of education. Technology education has great potential for contributing to the development of individuals in a technological society. However, this implies that we must begin to prepare a new kind of teacher — a “Technology Education” teacher. To do this means that significant changes must be made in our teacher education programs. Technical courses must help prospective teachers understand technology and how it influences our society. Concurrently, the professional sequence must be redesigned so that students are well grounded in the elements of teaching and the strategies and methods to develop and implement effective Technology Education programs.

The first part of this chapter will explore competencies the authors believe should be fostered in our youth. The second section will include a description of the principles that should be considered in developing a professional course sequence. The third section will explore experiences and strategies essential for those responsible for preparing Technology Education teachers.

**COMPETENCIES OF STUDENTS**

Our students must be prepared differently than they have been in the past. They must be given opportunities and guidance to develop essential competencies to fulfill individual potentialities and become effective contributing citizens. Although graduates of our public schools
need to possess a variety of competencies for an uncertain future, several competencies appear to be of prime importance. They are as follows:

**Self-Knowledge**

Perhaps at no other time in history has there been a greater need for people to better understand themselves. Rapidly changing societal conditions make it increasingly difficult for many people to cope and to adapt. Therefore, students must be encouraged and assisted in developing the ability to seek greater information and understanding about themselves as well as others (Parham, 1983).

Self-knowledge can be gained in many ways. However, it seems important that students engage in behavioral and learning styles analyses since the results will assuredly increase self-discovery and self-confidence. Further, students will gain individualized information and techniques from these analyses that will increase their ability to get along more effectively with others and to adjust or adapt to changing environmental conditions (Stum, 1983; Cavanaugh, 1981).

**Values**

During a period of unlimited technological and economic growth values have changed drastically. Our technological society provides, and indeed requires, a system of human interaction through which significant decisions must be made. Thus, new value systems are necessary. Students must rigorously examine their own as well as obsolete societal value systems. They must develop the ability to clarify and form values that are based on human relationships. However, even more important is the ability of students to act on a system of values that places human relationships in perspective with nature and the physical world. Therefore, clarifying values for making better decisions in a technological society should become an important aspect of teacher preparation.

**Human Interaction**

Humans have needs that involve interaction with other humans (Gale, 1970). Yet, it has been suggested that people are undereducated in understanding and working with one another (Strom, 1973). Our youth need to understand that the only way our nation can return to a more human course of evolutionary development and avert the destruction of our culture is through collective control of our destiny. We cannot leave the creation of new technology in the hands of a select few individuals and groups. Therefore, our youth must develop caring, humane attitudes toward all people. They need to be assisted in developing an open-mindedness and cooperative spirit to work effectively with others. They must also develop the ability to foster cohesive group action. For it is through
positive collective group action that alternative ideas and choices must be explored for developing new technologies and solving complex societal problems.

**Communication**

No single set of ideas is safe for determining a human future. The future is completely open to ideas and human decision-making and nothing can be taken for granted (Shane & Shane, 1974). But if students are to generate fresh ideas they must have the ability to communicate effectively. They must master important study skills and become critical readers, listeners, and observers of media such as books, films, recordings, and television. Yet, they must be able to do more than reproduce what was read, heard, or seen. As Dale (1972) emphasized, students must develop the ability to “... read between the lines” as well as to read “... beyond the lines” (pp. 65-66).

**Future Orientation**

It is generally agreed by educators that American youth are oriented toward the future (Singer, 1974). Although this is healthy, most educational curricula have been geared to the present and past (Toffler, 1974). This is no longer acceptable as the future continues to rush toward us. Our students must be encouraged to develop their future-oriented outlook and abilities. It is only through future-focused experiences that students will, as Shane and Shane (1974) wrote, “... recognize and explore possible alternative choices likely to create a more desirable environment for the human species” (p. 191).

**Problem Solving**

Youth will need to develop the competency to solve problems. As Coombs (1981) wrote “‘Tomorrow’s citizens must be effective problem solvers, persons able to make good choices, to create solutions on the spot’” (p. 370). In addition, students will be called upon to assist in identifying and solving societal problems that are typically interdependent and involve numerous complex variables. As societal problems are solved, others arise that demand careful study and attention. This dilemma is compounded further according to Kauffman (1976) “... because the problems we face are increasingly long-range problems which require anticipatory action, often far in advance of the crises point, if a disaster is to be averted” (pp. 8-9).

**Lifelong Learning**

Transcending all other competencies needed by students is that of continuing lifelong learning. The pace of change created by technological progress and the pressing need to solve societal problems will alone
require that students engage in independent learning on a continuing basis. At the same time, however, lifelong learning will be necessary for self actualization. No longer will schooling be able to prepare students for lifetime careers. Shane (1982) suggested, for example, that “... as many as half of the jobs in U.S. industry may be eliminated by 2000 or 2006 (p. 306). At the same time students must realize that the nature of work is changing. As Pogrow (1982) stated “Most future workers will increasingly engage in work that is service-related and technical in nature” (p. 610). Due to these changes, it will be common practice for our youth to change careers two or three times during their lifetimes (Starkweather, 1978).

**PRINCIPLES FOR DEVELOPMENT**

How can the professional course sequence contribute to developing the type of teacher we need — the Technology Education teacher? The authors have worked toward alleviating problems inherent in the typical “present and past-oriented” professional teacher education sequence. As a result, three major principles emerged that we believe can prepare new teachers for the world of Technology Education. They are as follows:

**Teacher-Directed to Student-Directed Learning**

Most students entering teacher education programs have been exposed to traditional industrial arts programs and teacher-directed instruction. However, we need a new approach if we are to assist youth in developing competencies discussed earlier. We must change our attitudes and practices to permit a gradual movement away from the teacher-directed mode to one that encourages student-directed learning. Therefore, as students progress through the professional sequence, they should be given the opportunity to assume greater responsibility for making decisions concerning what and how they are to learn. By following this principle, we have greater confidence that our learners will become active rather than passive participants in the teaching/learning process. Further, there is evidence that this principle will result in producing teachers who exhibit independent rather than dependent behaviors (Trent & Medsker, 1968; Katz, 1968; Wood, 1970).

It is also suggested that instructors, in beginning professional courses, set the objectives for technology assignments. For example, students may be asked to research selected topics such as robots in industry, communication satellites, production systems, and to prepare reports, charts and/or presentations on these topics. However, as the students develop confidence and experience related to studying tech-
nology throughout the professional sequence, they should be encouraged to select their own topics for study and for teaching.

**Learning About and Practicing Teaching Skills**

Many teacher educators are experts at lecturing to students about “how to teach” (Frymier, 1976). Surely, we cannot abdicate our responsibilities as teacher educators to discuss, explain and demonstrate a wide range of teaching methods and techniques to our students. However, this principle means that although we must provide information and direction, we must also allow students to practice the skills of teaching throughout every course in the professional sequence. Only in this way can our students develop confidence in a variety of techniques and in developing their individual teaching styles.

We might consider having students teach technology lessons that move from the concrete to the abstract as they move through the professional sequence. In early courses, students could practice selected techniques while teaching short lessons on “concrete” technology concepts such as designing a manufactured product or constructing a solar hot water heater. In later courses, lessons developed by students might move toward abstract technology problems and issues. These might include themes concerning waste management, housing, water, air, soil pollution, and transportation systems.

**Campus-Based to Field-Based Experiences**

As prospective teachers move through the professional sequence they should be learning about technology education content, activities, teaching methods, and techniques. Further, they should be developing greater confidence in their ability to design and implement technology-oriented units of instruction. However, no number of courses or campus-based experiences can replace real-life experiences gained in public school classrooms and laboratories (Barella & Henak, 1978). Pre-student teaching field-based experiences should become an integral part of all professional courses. Throughout the professional sequence, students should be given the opportunity to observe, participate, and actually teach units of instruction in public school settings. Some examples of Technology Education instructional units include the Evolution of Skyscrapers, Ocean Thermal Energy Conversion, Transportation Systems in Buildings, and Testing Industrial Materials. Through these experiences students are able to make informed choices about entering teaching as a career and are able to apply what they have learned and practiced in the campus-based professional courses. They are better prepared to enter student teaching and will be more eager to try new ideas including lessons and units based on technology-oriented content and activities (Barella & Henak, 1976).
ORIGIN OF CONTENT

Curriculum developers typically consider theoretical principles and historical practice. In the past, trial and error and task analysis techniques served reasonably well. However, today we can no longer rely on past experiences to solve problems confronting us in the future. Many conditions facing us do not have historical precedents. Five of these conditions are:

1. Technology has the power and impact to destroy humankind or the world as we know it today (DeVore, 1980).
2. Linear growth of technology has become exponential growth and in some areas growth is approaching its limits (DeVore, 1980; Meadows, 1972).
3. The needs of achievement and fulfillment are becoming increasingly important to people (Coombs, 1982).
4. The inertia of social acceptance and implementation of corrective measures to the level of effectiveness is great (Frieden & Baker, 1983).
5. The negative effects of decisions continue to maximize themselves long after corrective measures have been identified and enacted (Kauffman, 1976).

The characteristics of technological growth, level of power and impact, changing level of needs, and inertia of the effects are new phenomena in which there is little past experience for preparing teachers. Therefore, solutions to such problems will be found by paying greater attention to those who are keen observers of society, skilled scholars, and gifted theorists in areas relevant to the problems. The theorists can provide rational alternatives to solutions. The rational alternatives need to be adjusted with responsible intuition by a future-oriented citizenry willing to identify and plan the kind of future they want. Intuitive contributions help make rational alternatives appropriate and humane. This process will be referred to as rational-intuition.

Figure 5-1 illustrates the notion that past and present actions cannot be our focus for finding ways of preparing Technology Education teachers. The approach used to develop curricula cannot be personal observations by individuals with limited experiences and expressions of what I want to teach, what I know, or what I was taught. We will need to study the nature and basic needs of humans and society, characteristics of technology, purposes of public education, and ways people learn. Technology education teacher educators need to look to skilled observers of people, society, and technology. We must listen to scholars who are gifted and committed to finding truth in their areas of speciali-
zation. We should blend the theorists' perception with the personal perception of self and the world around us. This we feel is an application of rational-intuition.

Figure 5-1. The primary input into technology education curriculum must be the theories and principles found by scholars. It in turn must be tempered and made practical by the classroom teacher.

WHAT IS TAUGHT

The professional sequence includes all required courses beginning with an orientation to teaching during the freshman year through completion of student teaching at the senior level. The primary goals are to help students:

1. develop a personal theory
2. use instructional technology
3. develop a value system
4. develop a future orientation
5. become independent lifelong learners
6. develop a positive self concept.
Develop a Personal Theory

How a person reacts to life situations is determined by their system of beliefs. All individuals have a personal theory. A person’s system of beliefs shows, whether they are aware of it or not. As a result, people learn to predict how others are going to react in given situations. When interacting with others, people tend to select words and approaches to ideas and requests based on their knowledge of other people’s feelings and beliefs regarding the idea or the request.

These beliefs provide guidelines for confronting problems. A professional activity such as teaching, where a teacher affects thousands of lives throughout a career, must be defensible on some rational basis. Professional behavior demands a belief system that is comprehensive, internally consistent, and as accurate as teachers are capable of making it. Concerning teaching, Coombs (1982) wrote “...the primary difference between good and poor teachers lies in their belief systems (p. 5).” It is their belief systems that make up what Coombs termed a personal theory. In his book Basic Principles of Curriculum and Instruction, Tyler (1975) proposed a model for preparing a curriculum rationale. Tyler’s model was adopted and used for the personal theory referred to in this chapter and is shown in Figure 5-2.

![Diagram](image-url)  
**Figure 5-2.** Our personal theory is a composite of beliefs about students, society, subject matter, purposes of education, and psychology.
In order to form accurate, relevant, and effective beliefs about students, teachers must learn about human development. They must also learn about the needs, values and goals of people in general and particularly about students in their classes.

With a comprehensive and accurate view of society in the past, present, and future, teachers are better able to make decisions relevant to the real world and to the students’ future. An understanding of the subject matter requires an understanding of the current terminology, organization, trends, history, and the impact of technology. With accurate, relevant, and comprehensive beliefs about the subject matter, teachers are in a position to identify, select, and implement relevant instruction.

The purpose of education is to screen a collection of beliefs that help sort the relevant knowledge, skills, and attitudes to be emphasized in the time allotted to instruction. Growing knowledge about what motivates people and how people learn is the fabric of the psychology screen. The quality of the psychology screen determines the efficiency of the learning experiences. The psychology screen is that part of the personal theory that serves as a guide in selecting teaching/learning activities. The better we understand how people learn, the better we can design learning experiences.

The development of the personal theory is not easy and cannot be accomplished in a short period of time. It is not easy because it requires gathering enormous quantities of information through reading, watching, speaking, feeling, and experiencing the world and life. After this information is gathered, it takes considerable effort to synthesize it into useful theory.

**Use Instructional Technology**

Instructional technology is defined as the study of the efficient and appropriate practice of teaching. Figure 5-3 (p. 148) reveals the major elements in instructional technology and how they relate (Henak, 1974). Teachers must be effective in relating learning experiences to learners. They must also be aware of the learner’s educational background, intellectual abilities, preferences, level of social development, relevant physical characteristics, interests, values, beliefs, and feelings of self.

Technology education teachers need to have a command of the human adaptive systems and their relationship to the needs and purposes of learners and of society. They must be able to identify, select, and appropriate intended outcomes that have relevance and that will result in growth by the learner. Technology education teachers need to understand the structure and content of the universal technical systems of manufacturing, construction, communication, and transportation and
their productive processes (Snyder & Hales, 1981). The intended outcomes from Technology Education, however, must surpass the cognitive knowledge and psychomotor skills. Outcomes from Technology Education are designed to develop rational thinking and problem-solving skills. Laboratory activities, unlike in the traditional approach that focuses on the completion of a project, are used to test and demonstrate solutions to personally relevant technical problems.

**A Value Orientation**

The value orientation views values as a moral standard or norm that is considered to be worthwhile (Davis, 1980). We might hold a value of self-respect, a social value of democratic process, and an environmental value of a stable ecosphere. Rokeach (1975) described “terminal” values or worthwhile aims or goals and instrumental values as qualities which help us attain the terminal values.

Davis (1984) stated that “U.S. educators must acknowledge the responsibility of the public schools for teaching of civic but not of reli-
igious values” (p. 360). Civic values were defined by Davis in the following way:

By civic values I mean those attributes of character necessary for effective citizenship. Such values maintain the common good and assure the survival of the society (p. 306).

Many educators question whether teachers should even get involved in value education. Davis’ response to those educators was: “It is impossible for a school system to reflect no value system” (Davis, 1984, p. 359). Our values are reflected in what we emphasize in instruction, what we choose as evaluation criteria, the social environment of classrooms, reasons we give to explain our actions and evaluate the actions of others, and the way we instinctively respond to daily occurrences. Values are communicated with every action or inaction.

We cannot avoid teaching values. Learning about alternative values and standards and how they are developed can contribute greatly to improving the quality of life. When people make decisions and respond to them, they rely on their knowledge of the situation and on how they feel about the consequences of their behavior. In the battle between intellect and feelings, intellect will lose most often. It is feelings that guide people’s actions. Therefore, in preparing people to actively participate in the world for all people, it is important that we help to raise the level of morals and improve the clarity of values.

Many people have an additional concern that unless the schools help develop values, many individuals will receive no assistance at all. Davis (1984) said it this way:

All parents reflect their own personal values. But some — perhaps many — do not help their children to form conscious value systems (p. 359).

Helping students project and define what they prefer in the future requires the development of a value system. To raise the criteria for right-and-wrong above the level of pleasure or peer pressure requires that people be introduced to new values and moral levels. Davis goes on to say “Surely, values that celebrate civic responsibility and amiable human relations are better than no values at all” (p. 359). Certainly, values that focus on conserving our natural resources and lessening the impact of technology on our environment are worthy endeavors. Technology Education can develop people who view technical progress more in terms of bettering the quality of life than in simply producing something to make a profit. We need to focus more attention on problem solving. The prime emphasis should be on what ought to be done rather than on what can be done or what I want to do.
If it is true that teachers teach values whether they want to or not, then raising the level and clarifying values should contribute to improving the quality of life. However, some people are not being helped in value development outside the school. It seems that attention to values should at least be conducted in an informal manner. An informal approach would require that teachers:

1. Learn to distinguish between values that are religious or civic, universal or individual, and terminal and instrumental (Davis, 1984; Rokeach, 1975).
2. Learn about levels of moral development (Kohlberg, 1975).
3. Learn procedures used to clarify values, raise moral standards, and make moral decisions, (Simon, et al., 1972; Kohlberg, 1975; Fraenkel, 1977).
4. Learn to carry on value/moral education in a way that enhances the uniqueness of individuals and contributes to personal fulfillment.

A Future Orientation

In order to provide future oriented Technology Education, teachers must be future oriented people who possess the habit of looking ahead, have the skills of anticipation, and are able to help young people do the same. We can no longer focus on the past and present to prepare for the future. Changes in technology are occurring too rapidly. With accelerated social, technical, and scientific change, people feel powerless to control the future in any significant way. Since change is apparently unstoppable, people learn to manage it. If teachers are to help others in this task, they too must be able to manage change.

Change is becoming increasingly apparent in the teaching profession. In recent years, teachers have been confronted with integration, career education, Title IX, PL 94-142, the back-to-basics movement, curriculum projects of the 60's, and Jackson's Mill. Most recently they have been bombarded with the excellence-in-education movement, merit pay, computers, the information age, and a new emphasis on improving discipline in the classroom. Thus, it is quite clear that teachers of all subjects need to be able to manage change in their personal and professional lives.

Students and teachers should have the power to significantly influence their futures. What they need is the opportunity to develop inquisitive minds, to consider a variety of alternatives and develop a decision making capacity so they can choose the most appropriate option.

Research indicates that motivation and a sense of purpose is increased when people's expectations about their future and potency in
influencing their future raises. Concerning this Singer (1974) wrote “The FFRI (future-focused-role-image) is our self-image projected into the future, and it lends meaning to much of what we do in the present” (p. 21).

Teachers of technology education programs must be able to project themselves in the future if they are to set professional goals and work toward achieving them. When prospective teachers feel they have meaningful roles in society, their teacher education should become more relevant to them. Future oriented instruction should help prospective technology education teachers develop a future focused role-image and help them begin thinking more creatively about their contribution to the world.

The teacher’s task is difficult when selecting intended outcomes for instruction. An effort needs to be made to:

1. Ensure that a comprehensive coverage of technology is achieved.
2. Make the content personally relevant to the learner.
3. Include content that results in clarifying values relevant to the important issues, problems, and opportunities.
4. Select content that is useful in the future.
5. Contribute to the purposes of education.
6. Enhance the learnability of concepts.

A broad concept of evaluation is a significant understanding for a teacher to acquire. It entails more than giving tests, grading projects, and computing scores. Evaluation includes preassessment of the learner’s educational background in the subject and their achievement of prerequisites. Evaluation also includes an attempt to identify interests, needs, learning styles, behavior patterns, and social development information. This latter group of characteristics is useful in making instruction personally relevant and for setting up a learning environment that is more motivating.

The concept of evaluation can also be broadened by focusing on course objectives and making certain that all objectives are being assessed. By analyzing the course objectives, teachers may find that both behaviors and products should be observed. To evaluate behaviors, one must watch the student achieve. Products are evaluated by observing the model, paper, or solution to a problem. How the product was produced is not observed. By understanding the students’ needs, points of view, and talents, teachers as well as students are able to identify alternative products to demonstrate the students’ understanding of a concept. For example, one student may demonstrate an understanding of energy
conservation by writing a report on insulation, another by preparing a display, a third by producing a slide series, and a fourth by making a presentation.

To broaden the concept of evaluation, we might consider assessing the teacher’s performance, the students’ feelings about the instruction, and the selection of the intended outcomes. These tasks can be accomplished by asking other trusted people to view the teaching or by video taping one’s teaching and viewing it. Students’ feelings toward teaching can be obtained through perceptive observations or by requesting anonymous feedback on a formal course evaluation instrument or narrative.
An instructional strategy is the sum total of all the teaching-learning techniques that are guided by the instructional approach and sequence when implementing a module (Henak, 1984). Figure 5-4 illustrates the three components of an instructional strategy.

Teachers of technology education programs must be able to select and use a strategy to achieve their educational goals. The teaching strategy is an energizing force that brings meaning to goals of instruction and a means to achieving the intended outcomes of instruction. As Maley (1978) indicated the strategy may determine:

- the performance of learning
- what is learned
- level of understanding
- how well it is applied
- extent to which goals are achieved
- extent of further learning
- who among the students learn
- depth that learning penetrates
- relevance of the concept
- where and how learning takes place (pp. 31-32).

Maley (1978) further described three competencies needed in order to implement well selected and skillfully used methods. Teachers need to (1) have a broad range of methods available, (2) have skill in selecting appropriate methods, and (3) have skill in using them (p. 54).

The approach to teaching determines the degree to which teachers or students are involved in selecting objectives, teaching/learning techniques, and the pacing of instruction. This three dimensional concept is shown in Figure 5-5 (p. 154). For example, when teachers select the objectives, set the pace of instruction, and use teacher-directed techniques, the behavior would fall at Point A in Figure 5-5 (p. 154). However, when students make these decisions we are functioning at Point B. There are infinite variations between these two points.
Figure 5-5. Teaching/learning activity varies in terms of who determines objectives, teaching/learning techniques, and pace for instruction. Students and teachers can make the choices.
Instructional strategies should be geared to promoting independent learning. Frymier (1976) developed a concept of growth which is shown in Figure 5-6. The model reveals that education for independence includes at least two dimensions — freedom and equality. The continuum of freedom moves from choice to non-choice. Equality refers to an equal opportunity to make unique contributions to self and to society. The equality continuum travels from difference to sameness.

Teaching strategies that foster sameness and offer non-choice result in dependent people who do not grow. Strategies that allow choice and encourage diversity result in people who are independent and who do, in fact, grow. If a teacher makes all the decisions regarding objectives, techniques, and pacing (Point A in Figure 5-6), students become passive observers. But when students are making all of the decisions (Point B in Figure 5-6) they are active self-learners.

At Point A, the teacher is managing the students’ behavior with control and directives. At Point B, the role of the teacher changes to
facilitator who assists the student in the discovery of personally satisfying solutions to student-identified problems. This second approach increases freedom and encourages diversity. The teacher-directed approach is preferred for specific objectives. The student-directed approach is preferred when teachers are trying to develop uniqueness, self-concept, personal values, and for meeting individual student needs.

The sequencing of instruction cannot be avoided. Instruction is a planned progression of activities. Pertaining to this, Bruner (1966) wrote “There is no unique sequence for all learners, and the optimum in any particular case will depend upon a variety of factors including past learning, stage of development, nature of material, and individual differences” (p.49). There are a number of sequences available to teachers. But perhaps the most relevant relates to the structure of the subject matter.

Teaching/learning techniques can be viewed and categorized in three useful ways. The first is the type of student involvement. The second involves objectives to be achieved. The third concerns itself with past, present, and future.

Categorizing teaching/learning techniques with regard to student involvement includes presentation, action, and interaction (Henak, 1984). Presentation techniques including lectures, demonstrations, audiovisual presentations, and field trips keep the teacher active in disseminating ideas while students are passive receivers. The action techniques include projects, experiments, exercises, and guided observations. These techniques require that individuals or small groups become active in using materials, equipment, and ideas while the teacher is relatively inactive. Finally, interaction techniques involve an active exchange of ideas between two or more students or the teacher and students. These techniques include questioning, discussions, buzz sessions, brainstorming, seminars, interviewing, role playing, gaming, committees, and debates.

Most of the techniques can be used at all levels when teaching about the past, present, and future. Studying the future, however, involves anticipating the possible impact that changes may have on the population or environment. This area of study presents special problems for traditional teaching/learning techniques.

Teachers must have a range of potential techniques available with skill in selecting and using them to be effective. Developing skill in selecting teaching/learning techniques is a particularly complex and perplexing problem. Research findings continue to be ambiguous when attempts have been made to ascertain the effectiveness of one teaching technique over another. This, in large measure, is due to the myriad of variables in which teachers function.
All of the above techniques, under certain circumstances, will result in good teaching. Henak (1984), however, has provided a number of guidelines for selecting teaching/learning techniques. They are:

1. **Match students' activities with the behavior specifying the objective.** Try to transfer this principle to physical, psychomotor and social skills, and affective feelings as well.

2. **Provide variety** in teacher-directed activities and encourage it in student-directed projects.

3. **Plan active student involvement.** Plan this involvement at a personal need level as close to it as possible.

4. **Provide feedback.** This should be done regularly and as soon as possible.

5. **Provide a positive model.** Modeling is learning by observing others performing correctly.

6. **Plan activities that are appropriate to student readiness and needs.** Readiness can be developed and one does not have to wait for it.

7. **Provide challenge.** Knowledge of a student’s level of confidence in each area of interest is necessary if this guideline is to be applied effectively.

8. **Match activities with learning styles.** Give students opportunities to capitalize on their strengths. However, do not reject encouraging students to build on their areas of weakness.

9. **Involve students in direct, purposeful and when possible “real” experiences.** This will result in the most meaningful learning.

Skill in using methods is developed through experience. Prospective teachers need to learn how to use teaching techniques and to develop knowledge of self and values related to teaching/learning techniques. These achievements can be learned through a procedure of modeling. The modeling procedure involves the student in observing correct behavior that is performed live or on video tape.

Field experience is an invaluable source of problem confrontation and student discovery. This experience should be available to students throughout the undergraduate program. Designing classroom activities in the absence of field experiences places a tremendous burden on university-based professional courses.

Lectures and demonstrations still dominate industrial arts classrooms. The technology education teacher, however, will continue to use these methods for limited purposes. They must inevitably give way to a whole battery of action and interaction techniques that include role playing, discussions, gaming, computer managed and assisted instruc-
tion, and activities that immerse students in what are called “contrived experiences.” To learn, a person must get involved. As Dale (1972) so aptly put it, “Learning cannot be a spectator sport” (p. 9).

The physical environment consists of equipment, materials, space, and services that support the teacher’s instruction and the students’ laboratory activities. The functions of the teacher are to acquire and manage the physical environment. Every effort should be made to provide the widest variety of equipment, materials, space, and services that are relevant to Technology Education subject matter and manageable by the instructor. Flexibility should be the goal when adding to or modifying the physical facility.

Constant attention should be given to providing additional opportunities for students to experience a wider variety of experiences with technology. A highly functional physical environment helps students simulate real-world problem solving and decision making where alternative values, technical means, and social organization are considered.

The social environment is determined by the teacher. Concerning this, Dale (1972) stated that teachers must ask themselves “What are the best circumstances under which to develop continuing learning, to keep us on a rising curve, and to build a learning community? (p. 17)” Some learning environments are friendly, supportive, and energizing. Others are cold, threatening, pessimistic, and debilitating. Some learning environments encourage independence while others are dependence oriented.

Prospective technology education teachers must be effective in creating positive learning environments. The factors related to this are (1) meeting the needs of students, (2) building positive self-concepts, (3) creating challenging experiences, and (4) providing for a sense of belonging.

**Develop Independent/Lifelong Learners**

A primary goal of a professional sequence should be to help prospective teachers onto an upward curve in growth and to become independent learners for life. Several areas in which technology education teachers should continually grow are in:

1. Developing a knowledge base of technology, its origins, applications, future, and problems that are devoid of prejudice and bias.
2. Developing a functional mental filing system that corresponds with the “real” world so the person can accumulate, store, use, and generate new information.
3. Developing the capacity to deal with several alternatives and maintain a congruent value system.
4. Developing the ability to work efficiently and effectively with others to organize and apply ideas.
5. Developing a system of wholeness of their world and life.
6. Developing communication skills of speaking/listening, reading/writing, and observing/showing so that ideas, intentions, and actions can be shared with or learned from others.
7. Developing understanding of and skill in using new technology and equipment.

As change continues to increase, the volume of knowledge will mushroom. Because of this, the number of alternatives multiply and the needs of people change. Prospective teachers must be able to function effectively with society but independently of individuals and societal factions. Independent people must have the ability to:

1. Function and make choices independently of surrounding pressures while knowing about and living with the consequences.
2. Be socialized yet individualized so they can function cooperatively yet retain uniqueness.
3. Work efficiently and effectively with others to organize and apply ideas without being stifled or coerced.
4. Develop a sense of identity, uniqueness, and belonging.

To be fulfilled, people need to have a sense of achievement (Bruner, 1966). To achieve in teaching, Coombs (1982) believes that teachers must be proficient in and held accountable for the following areas:

- To be in command of the subject.
- To be honestly concerned for the welfare of students.
- To keep up-to-date on understanding persons, their behaviors, and the nature of learning processes.
- To be clear about purposes.
- To select methods of teaching consistent with the best beliefs about teaching (p. 170).

There is a way teacher educators can help prospective teachers develop the habit of lifelong learning. It is through the development of a Professional Improvement Program (PIP) (Barella, 1980). Professionalism is not something that "just happens" when individuals complete a teacher education program. We must point out to students that professionalism is something they must continually strive for through a conscious and direct effort. Therefore, a PIP should engage students in setting and achieving goals to help them become knowledgeable about those areas suggested above.
Teacher educators should encourage and assist students throughout the professional sequence in selecting goals, choosing topics for study, selecting resources, and identifying ways in which they can share their knowledge with others. By helping students to implement a PIP, we are also helping them develop the habit of continuous and gradual self-learning. When students are consciously seeking out and achieving new goals, they will be up-to-date and thus becoming truly professional technology educators.

**Develop A Positive Self-Concept**

Almost any teacher can recall when personal problems affected classroom behavior. A teacher’s successes or failures can cause changes in how a person feels about him- or herself. Thus, experiences in the classroom influence a teacher’s personal concept of self. The aspects of a teacher’s self-concept are the same as those of a student. To be self-actualized or self-fulfilled are consequences of four primary factors. They are:

1. **Positive view of self.** Good teachers seem to think of themselves as liked, wanted, accepted, able persons of dignity and integrity (Hamachek, 1969).
2. **Openness to experience.** Teachers who are open to experience are likely to be more receptive, aware, and sensitive to students and their surroundings (Hunter, 1967; Hamachek, 1969).
3. **Identification and belonging.** Teaching is a human, social activity. Emotionally stable teachers are self-confident and cheerful and enjoy active contact with other people (Coombs, 1978).
4. **View of others.** Research has shown that good and poor teachers view students in different ways (Ryans, 1960). Good teachers tend to have more favorable opinions of students than do poor teachers.
5. **Personal need and teaching.** Fulfilled teachers are likely to be personally happy and fulfilled. They are also stimulating, therapeutic, and constructive (Ryans, 1960).

**HOW IS IT TAUGHT?**

Prospective technology education teachers will become involved in all three domains of learning as they grow and develop independence. The cognitive, psychomotor, and affective domains are involved in clarifying a personal theory, in using instructional technology and in broadening professional knowledge. The lower level objectives in each domain cannot be neglected in an effort to reach higher level objectives. Time
needs to be made available for allowing students to build the necessary knowledge base before higher level objectives can be achieved.

Students should have individualized printed references and recorded materials available to provide necessary knowledge that is needed to solve professional problems. Instruction in lesson planning, evaluation, equipment requisitioning, and other teacher tasks should be available for students as needed. Instruction can be guided with individualized devices, learning guides, and computer assisted instruction. Other individually guided instruction formats are potential means to guide students in self-directed learning activities. These materials are behaviorally oriented and can be designed with specific objectives. However, rather than have the learning guides serve as the central thrust of the teacher education program, they should be supplementary to reaching higher level objectives. Students should be encouraged primarily to focus on solving professional problems. To solve the problems, students need background information and skills. If the background information is the central thrust, students may learn to perform isolated tasks but lack the ability to apply the new skills and knowledge to solve the professional problems.

To provide the conditions in which these competencies can be developed entails three functions. These are (1) creating an atmosphere, (2) providing information and experiences, and (3) facilitating learning.

Creating a Social and a Technology-Based Atmosphere

A technology-based atmosphere in the classroom begins with the verbal expressions and expectations set by the instructor. Teacher educators must talk to students about technology concepts, problems, and issues in an enthusiastic and positive manner. Further, they must make their expectations about technology activities and assignments known to students.

The technology-based atmosphere can also be enhanced when the teacher educator uses a variety of examples in their teaching. These examples may include analyzing manufactured products in terms of their function, safety features, aesthetics, and recycling potential, showing how aircraft operate by demonstrating with a model and by constructing a "draftometer" to demonstrate improperly weatherstripped doors and windows. Other ways to create a technology-based atmosphere include the use of visuals such as charts, posters, cartoons, displays, published articles, as well as instructional materials. This type of atmosphere is then brought to "life" by student developed presentations and teaching activities.

Teachers at all levels could avoid much frustration and greatly improve the teaching-learning conditions if they would accept their students as they are with their lack of experiences, knowledge, skills, interests, and biases. Teacher educators should start from where students
"are" rather than from where they "should" be or where instructors "think" they are.

The learning environment can be improved if barriers to learning are removed, modified, circumvented, or neutralized. Sources of barriers appear as difficulties in approaching subject matter such as an uncomfortable or unpleasant physical environment, unpleasant consequences for effort expended, administrative demands of curriculum, and as opinions, biases, values, feelings, and habits of students.

Teachers can create a more conducive atmosphere by reducing the threat and increasing the challenge. Instructors give away their attitudes with words or actions, through questions asked, encouragement or discouragement offered, support provided, enthusiasm exhibited, and by the acceptance or rejection of ideas.

Providing Information and Experience

Teachers are regarded as knowledgeable people because imparting information is what they supposedly do best. Traditional teachers are experienced at lecturing, making assignments, and giving demonstrations. However, if information is to be internalized at any significant level, students must experience the concept, skill, or attitude in some way. Typically, there are two ways to present a concept, skill, or attitude. First, the content can be cast in a problem solving experience. The problem should be a "real" problem with a solution to be discovered rather than an "artificial" one with an answer to be found. The best problems are spontaneous and identified by students from life experiences and questions. For example, the development of a local landfill could serve as a topic for discussion among students. The discussion might focus on the potential problems to the community. In this way students are not only presented with a real technological problem but they will be learning to anticipate problems rather than merely reacting to them.

Creative teachers are able to set up simulated situations and teach with problems. Another type of problem may be a curriculum problem. Here the teacher educator might set the stage for developing a Technology Education program by having the class serve as a simulated school or district curriculum committee. This "committee" would be given the charge of developing a curriculum guide that might include a philosophy for Technology Education, a description of selected technology-related courses, teacher and student activities, audio-visual resources, and reference books.

The second method of providing information and experience is to concentrate on structure rather than facts. It is easy for teachers to concentrate on facts because there are so many and they are easy to identify and test. Principles or elements of the structure are relatively
few in number. In addition, it is usually easier to lecture on facts than it is to create and prepare the materials to carry out an activity. Finally, there is less risk in giving a lecture than in implementing a problem solving activity. The teacher knows how a lecture will go because they are in control. The activity, however, is under the control of students and the outcomes are less predictable.

When teachers are preoccupied with such things as neatness, punctuation, facts, format, grades, and conformity, students soon learn what is important. Teachers who value creative solutions, independence, attitudes, values, beliefs, opinions, and uniqueness communicate a different message. Current pressures on being educationally accountable and on competency-based teacher education seem to be barriers to concentrating on structure.

Concentrating on a functional structure aids learners to organize the facts into a mental filing system. This type of learning is cumulative, simpler to conceptualize, more easily transferred, and assists the learner in discovering new relationships and knowledge.

**Serving As A Facilitator**

Historically, the teacher has served as a provider of information. Only recently have teachers concerned themselves with meaningful student initiated activity. Currently, few teachers are skilled facilitators of learning. According to Coombs (1982) the function of facilitating is “... the most crucial and the most neglected aspect of teaching (p. 86).”

Teachers have traditionally used the doctor/patient model. They have diagnosed what needed to be learned, described the needs, and prescribed the curriculum. In the case of the doctor/patient model the patient is present. In education, too often, the learner is neither present nor seriously considered. What is needed in all education, are teachers who are prepared to serve as presenters and also as facilitators of learning.

Teachers serve as facilitators in many ways. For convenience, only two formats will be discussed — the one-on-one and discussion techniques. First, teachers can help students gain personal meaning by suggesting new and more fruitful ways to solve problems, encourage curiosity, and extend awareness by encouraging students to venture into new experiences beyond the unknown. Discussions with students are helpful in obtaining alternative views. Few significant learning experiences have come about without interacting with other people.

Discussion groups may serve two purposes. The first is to make a decision by arriving at a consensus and plan of action. In this process, there is always the possibility of coercing or stifling one or more members of the group. To resolve the problem, new rules for group action are needed. Methods to ensure full participation have been developed
and used successfully in industry. The techniques used in worker involvement groups can be easily adapted to the educational setting.

A second purpose for a discussion group is to explore ideas. Maley (1978) described the applications and implementation of the seminar approach. The seminar is a formalized, student-directed interaction technique that is useful for exploring ideas and in obtaining assistance in solving problems.

Dale (1972) described six scientific principles that affect the productivity of facilitators of learning. They are catalyst, synergy, symbiosis, critical mass, heurism, and serendipity (pp. 11-12). A description of these principles follows:

1. Catalyst — A catalytic agent causes changes by just being there. Teachers are sometimes like that. Just being there makes things happen.
2. Synergy — The elements operating in a synergistic situation combine so that the whole is more than the sum of the parts: two plus two make five.
3. Symbiosis — This means living together for mutual benefit. When teachers and students work together in a helping relationship an ecological balance is created.
4. Critical mass — This is broadly defined as the least amount of fissible material needed to cause a chain reaction. To employ this concept teachers would need to be skilled in providing just enough information and challenge to send the learner on a self-motivated and directed learning experience.
5. Heurism — This principle allows the student to experience the "Eureka" or "I found it" feeling. The teacher does not provide the answers, instead helps the learner to discover them.
6. Serendipity — This is the bonus for persistence. It is something that is found by accident when it was not expected (pp. 11-12).

Changing Self-Concept

Self-concept is learned and because of this it can be unlearned and changed. However, it is neither quick nor easy. It has been suggested that self-concepts can be changed through personal experience (Coombs, 1982). We learn to be effective by actually being effective with other people. Thus, our level of effectiveness is observed by our level of success.

Another way of changing self-concept is through vicarious experience like drama and reading. A large selection of self-help tapes, books, and other materials are available to give people help and examples in self-understanding. Included in many materials are suggestions for activities that will provide practice and personal experiences that can contribute to changing how one thinks about him or herself.
A third technique for change is personal confrontation. This requires that a person come face-to-face with a personal belief about one's self. If the belief turns out to be false most people would probably re-evaluate the belief.

In order for any of the preceding techniques to be successful, they need to be braced up with personal experiences. Anyone interested in improving will need to focus on the improvement and will also need positive feedback from others.

**Sequencing**

Instruction consists of leading students through learning experiences to help them grasp, transform and transfer what is learned into personal meanings. These are usually several sequences that facilitate learning for students. The optimum sequence will depend upon a variety of factors. Among them are past learning, stage of development, nature of material, and individual differences.

There are at least two bases upon which sequencing can be built. The first is related to the nature of the subject matter. Here we sequence on the basis of what content may be of most interest to students first. Also, we select content first that is most relevant to students based on their present level of knowledge and experience and then sequence other content to build on this. The second base is oriented around student growth and becoming independent. Sequencing here may include initial problem solving situations based on selected subject matter. In this type of sequencing, the goal is to get students involved from the start. The problem solving situations should be geared to promoting student growth and encouraging the development of independent learning.

Posner (1978) analyzed five principles useful in sequencing subject matter experiences. Of these five, three sequences have intuitive validity. Sequencing of subject matter can be based on the feeling of need. Schedule those units that seem to be of most concern first. For example, a unit on preventing and handling of classroom disorders may precede experiences in professional associations.

If problems, principles, or tasks of teachers have been organized into a conceptual structure, then instruction can be based on Bruner's (1960) spiral curriculum theory. Students would progress from learning the basic elements of the model early in the program and build on that structure throughout the remainder of the program. This sequence could be used to help students develop personal theories.

A third relevant structuring principle is a logical sequence in which a prospective teacher develops knowledge about a concept, skill or value before applying, using, or accepting it. Lower level objectives, with behavioral teaching methods, should gradually give way to high level objectives where humanistic-perceptual psychology principles are used.
The second basis for sequencing is oriented around growth and independence. As teachers in preparation draw closer to their first teaching position, it becomes increasingly imperative that they develop the capacity to exhibit constructive forms of teacher behavior with a minimum of supervision. The first application of this principle relates to student-directed versus teacher-directed experience. It seems reasonable that as students mature, learn, and approach the time when they will work with a minimum of supervision, they should receive progressively less supervision from faculty as they move through their teacher education experiences. A second way to help students become independent and in charge of their own growth is to have them work in field-based settings as they progress through the program.

WHERE IS IT TAUGHT?

The day when an instructor can go into a classroom with four walls, thirty desks, and a chalkboard and teach prospective teachers how to teach, using a briefcase full of notes, is long gone. A well equipped professional laboratory is needed for teachers in preparation to solve professional and instructional problems with a minimum of barriers. Centralized professional facilities in a library may appear to have economical advantages. But educationally they present numerous barriers. It is hard to believe that students would prefer to leave the professional classroom, go to a library to view a "how to" filmstrip and then return to the professional classroom for follow-up activities. It makes more sense, educationally, to have the instructional materials located in a professional laboratory along with media production equipment. Many other barriers could be cited. A professional laboratory should be available to teacher educators who are familiar with Technology Education. This professional laboratory should be equipped with projection equipment, audio and video recording/playback systems suitable for individual and group viewing and listening. There should be an up-to-date selection of instructional materials such as periodicals, books, and references dealing with relevant topics about the future, technology, and professional education.

A selection of individualized instructional materials should be available to provide students with information on how to perform skills such as planning lessons and for preparing their own instructional materials. A method of information and retrieval must be included if efficient use of the materials is to be realized. When solving professional problems, an access system needs to be available. It may be in the form of a card catalog, computer filing system or some other retrieval system. Equip-
ment for producing high quality thermal and diazo transparencies, photographic slides, educational displays, video tapes, filmstrips, picture packs, and perhaps single concept super 8 motion pictures should also be available.

The space needs to be flexible so that large group, teacher-centered learning activities can be conducted as well as individual learning activities, small group discussions and micro-teaching activities. Finally, the instructional laboratory should allow for student production of instructional materials.

**CONCLUSION**

Educators are recognizing that Technology Education has great potential for contributing to the development of individuals in a technological society. Because of the rapid rate of change, it seems clear that our public school students will need different competencies for coping with uncertainties related to self-knowledge, values, human interaction, communication, future orientation, problem solving, and lifelong learning. However, to develop these competencies means that Technology Education requires a new kind of teacher — a Technology Education teacher. As a result, teacher educators must assume a new commitment and dedication to preparing the Technology Education teacher.

The authors have emphasized that greater attention must be devoted to the development of a professional course sequence that will contribute to preparing the technology educator. It seems imperative that the professional course sequence be designed according to three principles:

- If we are to develop a new kind of teacher capable of assisting youth in developing the competencies discussed, we must initiate changes. These changes must permit a gradual movement away from teacher-directed instruction to one that encourages student-directed learning.
- We must, of course, continually provide information and direction to prospective teachers. But we must allow students to practice the skills of teaching throughout every course in the professional sequence.
- No number of university-based courses can replace real-life experiences gained in public school classrooms and laboratories. Pre-student teaching field-based experiences should become an integral part of the professional sequence.

Technology education teacher educators responsible for the professional sequence will have to adopt new practices. Instructors of professional courses and experiences must be up-to-date in terms of studying
the nature and basic needs of humans and society, technology and its related concepts, issues and problems, the purposes of public education, and the ways people learn. No longer can curriculum development approaches be based on personal observations. Technology educators must be able to understand the structure and content of the universal technical systems of manufacturing, construction, communication, and transportation and their productive systems.

The professional sequence must also provide experiences for students that will help them grow as individuals as well as professional technology educators. As a result, they must engage in activities that will help them to (1) develop a personal theory, (2) use instructional technology, (3) develop a value system, (4) develop a future orientation, (5) become independent lifelong learners and (6) develop a positive self-concept.

Throughout their professional course experiences prospective teachers should engage in solving professional problems. Problem solving situations should help students to understand and be able to create an atmosphere for learning, provide information and experiences and become facilitators of learning.

The writers believe that a professional laboratory should be available to teacher educators who will be preparing technology educators. This laboratory should be well equipped. There should be an up-to-date selection of instructional materials.

This self-contained laboratory should allow students to become involved in solving professional and instructional problems with a minimum of barriers. It should help in providing students with many opportunities to engage in a wide variety of experiences with technology.

We believe that a sound professional sequence is essential for preparing Technology Education teachers. Therefore, our challenge to those who prepare technology educators is to improve on what we have written. Yes, improve it, build upon it, and more importantly act on it. Dale (1972) described a predictable result if we choose not to act when he stated that, "It would be sad indeed if the epitaph of this generation should read: They knew the way but they lacked the will (p. 13)."

REFERENCES

The basis for any curriculum development effort should be a logical statement of philosophy and rationale. A statement of philosophy provides the foundation for the sphere of thought and activity on which curriculum is developed. In the absence of a developed philosophy, the curriculum becomes merely a mechanical means of identifying predetermined skills in young people. Typically, decisions concerning skills are based on and conform to past experiences and practices. Rarely are the origins of our beliefs examined through careful reflective thought. Instead, efforts are devoted to finding arguments to justify presently held beliefs.

A comprehensive philosophy and rationale for the study of technology was developed in Jackson’s Mill Industrial Arts Curriculum Theory. The following discussion and recommendations for a technical sequence and activities in a technology-based undergraduate teacher education program is based on the Jackson’s Mill theory. Therefore, a brief review of two pertinent definitions follows:
HUMAN ADAPTIVE SYSTEMS

The evolution of humans and their social and technical orders can be understood by analyzing three human adaptive systems: ideological, sociological, and technological. See Figure 6-1. Ideological systems are concerned with the values and beliefs of society. Sociological systems are patterns of societal endeavor, characterized by social organization and regulation. Technological systems pertain to the technical means of manipulating the physical world to meet basic needs of survival — food, clothing, shelter — and providing other goods, services, and means for extending human potential.

According to Jackson’s Mill theory, a study of the various systems humans developed to adapt to their environment and extend their potential for survival should include a study of technology. The study of technology as a human adaptive system would include a study of the tools, techniques, resources, and technical systems humans use to adapt to their environment and extend their potential for survival.
The universal technical systems are Communication, Construction, Manufacturing, and Transportation. The technical systems are basic to every culture and society. The systems are related to each other, but are unique in the types of questions and problems pursued and in their structure, concepts, and goals. (Synder & Hales, Note 1)

While it is convenient to divide and sub-divide systems for analysis, it is important to realize that the total system is greater than the sum of the individual sub-systems. Therefore, the sub-systems must be reunited. Interrelationships that exist among the components must be demonstrated to fully comprehend the study of technology. The basic premise suggests that knowledge of the four universal technical systems begins with the study of materials, tools, and techniques at varying depths and breadths within each individual sub-system. Eventually, at the highest level, this study would culminate in an understanding of interrelationships between the sub-systems to demonstrate human adaption through technology.

Recommendations for content, activities and sequencing of information were based on the following assumptions:

1. There is a need to identify logical consistent units and sub-units for the four universal technical systems to provide an efficient guide for developing content.

2. There is a need for young adults to become technically literate through:
   a. understanding that specific resources are needed in any human endeavor.
   b. manipulating necessary resources in a given manner and applying certain skills in the uses of tools and machinery to complete specific technical processes.
   c. comprehending how industry applies a variety of technical processes to produce goods and/or services.

3. There is a need for young adults to become technologically literate through understanding the use of resources, the application of technical processes, and that production of goods and services creates a significant technological impact on society and/or environment. (Jones, 1983)
A PROPOSED TECHNICAL SEQUENCE

A technical sequence should provide the learner with opportunities and experiences in developing technical skills and knowledge. Initially, the development of a scope and sequence model is beneficial. A logical model provides direction for curriculum developers. A sequence is presented for your perusal.

A Scope And Sequence Model

One method for organizing curriculum is the development of a new scope and sequence model or the adaptation of an existing one. A suggested scope and sequence model for a four-year technology-based undergraduate teacher education program is presented in Figure 6-2 (p. 175). The reader should note that this particular model is designed for the “technical” aspect of the undergraduate program. The “professional” aspect of that program would occur simultaneously.

The scope and sequence model visually illustrates the natural “unfolding” of information, both technical and technological in nature. Initially, students are confronted with a broad range of ideas, basic skills and new information. Students develop an awareness of the existence of “Technology” in terms of human development and are introduced to the sub-systems.

Information of a technological nature includes the study of the individual sub-systems. An efficient method of presenting this information is an illustrated lecture using contemporary media. An overview of the systems including a short history, the state-of-the-art and a look at the future is included. It is suggested that the information be presented in a “story” format rather than becoming bogged down in a mass of details and rote memorization of dates. A single course would suffice to adequately present introductory information on an “overview of technology.” A course of this nature also may satisfy a social science requirement for undergraduates throughout the university.

Concurrently, the student would be introduced to a variety of materials and processes in the form of “basic skills” in the technical areas of Communication, Construction, Manufacturing, and Transportation. One cannot assume that all students have a background in technical courses from the public school. This may be the student’s first contact with tools and equipment in our discipline.

Introductory information should be presented in a series of courses. Ideally, two introductory, technical courses are needed in each of the sub-systems. (Lauda & Wright, Note 2). For example, students need considerable information on materials (such as characteristics and properties) and on processing (such as separating, forming, combining and finishing) in Manufacturing. This technical information should include a large number of hands-on activities.
Figure 6-2. A technology-based program should introduce the student to a broad base of information, then provide an opportunity to develop specific technical skills, and conclude with some major experience to enhance problem solving abilities. (adapted from Wright’s model, 1977)

Students need to identify specific areas of interest, called “concentrations.” Concentrations become specific technical areas for teacher certification. This portion of their program should help them develop advanced technical skills in one or two of the universal technical systems. These, in turn, become the student’s areas of concentration for certification. During this period, introductory-level “problem solving” skills should be an integral part of the curriculum. Instead of the
demonstration/imitation methodology so prevalent in our discipline, we must focus more responsibility for "learning" onto the learner through problem solving experiences.

Nearing completion of the in-depth technical sequence, students could engage in advanced research. A "research and experimentation" course should be an option for the more accelerated student. A course in "research" would provide opportunities for advanced study to undergraduates. While the focus of the course would center around research, individualized study in a variety of technical areas could be accomplished.

All students should complete a course as the "capstone" experience. A capstone course would provide information and experiences on how the universal technical systems work together. Completion of this experience provides study and practical experiences in an enterprise approach that emphasizes interrelationships among technical systems. This experience demonstrates how systems compliment each other under the aegis of technology.

Constraints

Curriculum planners often work under certain constraints in which they have little or no control. Perhaps the most common example of a curriculum constraint is state teacher certification regulations. If certification includes the sub-systems, e.g., Communication, the curriculum developers have a far greater flexibility to design a contemporary program. For example, the certification area of Communication should contain equal amounts of study in both the graphic and electronic forms of communication.

If a particular state is certifying the traditional areas, then curriculum planners have less flexibility in program planning. However, planning for a technology-based curriculum can still be accomplished. Content selection for a technology-based program, in this case, includes all components identified in the certification requirements. In addition, the matching of credit hours with certification requirements may be accomplished internally, using a equivalency chart or sheet through an administrative process.

Summary

The scope and sequence model for a technology-based teacher education program provides a logical and efficient tool for planning. The broadness at the beginning of the model provides students with an overview of technology and an introduction to skills. The narrow middle emphasizes the need for in-depth study into technical systems. Finally, the re-broadening at the upper end allows students to practice knowledge and skills acquired during the previous study.

This information, both technical and technological, will provide the new teacher with a solid educational background in the study of tech-
nology and enable them to carry that information into the public schools. Public school students should become more technologically literate; an educational goal generally accepted in our discipline.

**AREAS OF STUDY**

The adoption of Jackson’s Mill theory provided a sound base to structure curriculum. The appropriate “titles” for the technical areas of study are Communication, Construction, Manufacturing and Transportation.

**Systems Approach**

The “systems approach” to developing curriculum is an efficient and justifiable method (Bensen, 1980; Ray, 1980). The recommendations and sequencing of content follow the systems model of input-process-output-feedback. The scope and sequence of content must take into account all four parts of the systems model. See Figure 6-3. To leave any part out and assume it will be included in the curriculum will result in an incomplete and unbalanced curriculum model. Incomplete models are difficult to understand, cannot be rationalized by the user (teacher), and are usually discarded.

![Diagram of Universal Technical Systems](image)

**Figure 6-3.** A suggested curriculum model for a technology-based program. This model is an application of the systems approach to curriculum development. (adapted from Jones’ model, 1982-83)

The systems model used in this chapter is complete. The reader should be aware that throughout the following content suggestions for an undergraduate technology-based teacher education program, students will be confronted with:

- **Resources** . . . . Primarily tools and materials. May include such things as capital, humans, knowledge, finance, etc.; inputs to the system.
- **Processes** . . . . Using the tools to process materials in the system.
- **Application** . . . . How industry uses the process to produce goods and/or services; the outputs in the system.
Impact ........ How the outputs affect the entire system, i.e., the environment and/or society. This is the feedback in the system. ("Illinois State Board," 1983)

Organizing Content

Suggestions for content are identified in each of the technical systems. Course titles and specific sequencing will not be presented. Course titling should, obviously, fit the course and should be done on the local level. When designing courses, unique constraints are apparent at any given university. For example, scheduling may be a constraint. It would be inappropriate for the authors to suggest specific scheduling since schedules differ radically from campus to campus. Scheduling and titling are the responsibility of the local curriculum developers and/or administration.

The authors have designed a format for suggesting content. The format is based on a series of three "levels". Each level corresponds with the scope and sequence model presented earlier. Information will be presented from the standpoint of both technical and technological content. The purpose is to provide the reader with an understanding of how the information, both technical and technological, interrelates simultaneously throughout the program of study. This, in turn, may be used as a suggested scope and sequence for planning a technology based program. For purposes of clarity, an explanation of each level follows:

Level I. . . Introductory information in all areas of study. Completion of this level should provide the student with the necessary technical skills and information to teach equivalent introductory courses (grades 7, 8, and 9) in the public school AND provide an information base for further study in the technical systems. Students should gain an understanding of technology, how the particular universal technical system fits into the "systems" model, and the conceptualized model of the technical system.

Level II. . . Focuses on the development of technical skills and problem solving skills in selected technical areas for purposes of completing teacher certification requirements. Continuing study into the technological effects of the system including environmental and societal and introducing the student to technical developments, human resources and economic ramifications.

Level III. . . Advanced applied research and study of the interrelationships among the systems. Applying problem solving techniques in actual classroom/laboratory situations in a capstone experience.
Figure 6-4. Studying the universal technical systems includes an understanding of both the technical and technological aspects of each system. Broad-based information is presented at the lower level, skills are developed during the middle level, and the students should progress to a high level of problem solving abilities upon completion.

There will be some overlapping of information and content among the four universal technical systems. This overlapping is most notable at Level III. However, it is this overlapping that truly brings the four systems together! The unique aspect of the technology-based approach is that all students do not accomplish exactly the same goals as with the "lockstep" method. At Level III, students concentrating in Communication are accomplishing significantly different objectives than students of Manufacturing, although they may be enrolled in the same course. For example, two students may be enrolled in a Research and Development course. One may study satellite communication as a project. The other may study programmable controllers used in Production. Level III experiences will provide opportunity for study in diverse areas while working to accomplish the same goals.

**COMMUNICATION TECHNOLOGY**

The study of communication must be an inherent part of the curriculum if one is to focus on human adaptive systems in general, and specifically the universal technical systems. Communication, that is, the transfer of information and the effects of the transfer, has been conceptualized numerous times in the literature. Conceptualization is a necessary step in curriculum development. However, conceptualiza-
A program in Communication should provide the learner with an overview of the technical and technological aspects of that system. Completion of specific portions within the overall program will provide the learner with a limited overview of the Communication system. However, completion of the program of study will provide an opportunity for the learner to:

- become technically competent in a number of communication processes including an understanding of and manipulation of the necessary resources needed to complete the process.
- obtain the knowledge necessary to make decisions concerning the impact of communication on society and the environment.

For purposes of this discussion, the reader should refer to Figure 6-5 (p. 181). It should be noted that only Level I and Level II information will be presented here. Level III content will be addressed later in the chapter.

Level I Communication activities and content should introduce students to a variety of materials, tools and processes. In Level II, the student should become technically competent and obtain an understanding of the technological ramifications of the system. In doing so, the student will gain technological literacy. Content and activities from the technical aspect of communication should focus on the resources (equipment and materials), the technical process (graphic and electronic) and the industrial application (Jones, 1983). Categorizing technical processes into Graphic and Electronic is a convenient means for identifying content.

It is understood there are other "forms" of communication. An obvious one is language, or the spoken word. However, it has been our technical heritage that ensured our place in education. The "technical" aspect of our programs make us unique and different from other disciplines such as the social sciences. Our goal should focus primarily on the technical aspects of communication.

Suggested activities for the Communication sequence will be presented for each level. The following activities are a minute sampling available to the curriculum developer and instructor. In each case, suggested activities will include both the graphic and electronic forms of communication.

Communication Level I. Activities for Level I courses should be introductory and provide the student with opportunities to try a variety of new experiences. Students should use the tools and materials commonly found in the laboratory. Processing materials, gaining a basic understanding of how to operate various equipment, and understanding how equipment functions is necessary content for Level I.
Figure 6-5. The communication systems model illustrates the progress of content through levels I and II. Level I contains broad-based information. Level II focuses on the development of skills. Note that varying types of technological information is presented during Level I and Level II course work.
New teacher-education students might have had no background in technical courses while they were in high school. Therefore, Level I activities should assume no prior background on the part of the student. Non-lab classes may also be technical in content; i.e., technical content can be presented. There are specific take-home activities that can be completed as part of a non-lab class; for example, the construction of a model.

Suggested Level I lab activities are as follows:

Using a participatory decision-making technique such as the "Quality Circle," identify major concepts or trends in Communication. For example, subliminal seduction, use of satellite dishes (downlinks), truth in advertising, or recycleable materials for printing to name a few. Assign subgroups of 4-5 students within the class. Sub-groups must select one of the final topics as identified by the class.

Each sub-group could complete the following activities while focusing on their particular topic:

1. Design a dynamic, high-quality display to present information about their topic. This display should move, light up, or talk to the viewer and should not be static (such as a simple poster or bulletin board). The display should be set up in a high traffic area such as a main entrance to the building or the University Union. Use a "suggestion box" technique or live interview to obtain data from individuals viewing the display. Questions should be related to some aspect of Communication, e.g., "What does this display communicate to you?" or "What part of the display has the most/least impact on you?" Present a synopsis of the data to the class.

2. Develop a visual presentation on the same topic. This presentation should include slides with a music background on cassette tape. Presentation should be live, limited to approximately 10 minutes, and presented to the full class. (Note: It is suggested that at this point, slides should be sent out for commercial processing.)

3. Write a commercial for a fake product that includes color. Produce the commercial on video-tape for television broadcast, on cassette tape for radio broadcast, and develop an advertisement for some type of print media (newspaper, magazine, etc). Have students report on changes in emphasis for the product with regard to color and using the different technical systems.
Suggested Level I classroom activities are as follows:

Assign four sub-groups to periods of time, e.g., Group A works within the time frame of 4000 BC to 1750 AD, Group B from 1751 to 1900, Group C from 1901 to “Today,” and Group D from “Tommorrow” to the year 2050. Individual members of the sub-groups should identify different past or future technical developments in Communication that matches their assigned time frame. This will eliminate overlap of technical developments.

The following activities should take place upon identification of individual technical developments:

1. Each student should construct a model of their particular technical development. Models should be simple, small (approximately 1 cubic foot), and should not be constructed in the laboratory.

2. Each student should write a 2-3 page research paper on their technical development. The report should be typed, referenced, and, if possible, checked with a “Writing Center” often sponsored by the English Department.

3. Students are responsible for finding or drawing a picture of their technical development. The picture will accompany an information card (a brief statement typed on an index card) about the development. Using felt-tip markers, rubber cement, newsprint, and other assorted low-cost materials, have each group produce an historical timeline of technical developments developed during their time period. Timelines should range from 6-8 feet in length. Display pictures and information cards on the newsprint and display them in a prominent location. The total display will portray the history and near future of Communication.

Communication Level II. Level II activities include practice on introductory skills and developing in-depth skills. Students completing this phase should understand that industry uses a vast combination of materials, tools, and processes to produce a product. In addition, there is a need for introductory information related to research and development (R&D) and the in-depth planning needed for the total production of a product. Planning should focus on producing a product both in large quantities (periodicals, newsletters, etc.) and a single product to reach a large audience (television or radio production). These two forms of media will continue to enhance the student’s knowledge of graphic and electronic communication.
Suggested Level II lab activities are as follows:

1. Form a publishing company. Include a management team to head up the operation, editorial and artwork, pre-press operations, production (printing), finishing (binding and shipping), and marketing. Develop a journal or tabloid-style newsletter with a minimum run of 200 copies. Have each student write one piece for the journal in addition to other responsibilities. Write the text on a word processor.

2. Working in cooperation with the local television studio, form a television production company. Company structure should include a director, producer, technical assistants, camera operators, lighting, special effects, visual (slides), sound people and stars. Produce a half-hour documentary on your program for use in recruiting.

Suggested Level II classroom activities are as follows:

1. Have students write scenarios on the future of communication. Include projected changes in tools, materials and processes plus the technological impact, i.e., the effects on environment and society.

2. Develop an in-class paradigm on how the “scratch plough” caused the eventual global change in the structure of human culture. Identify what role “communication” had in this change.

3. Focusing on some technical aspect in communication, have students select a topic of interest, conduct necessary research, and develop a paradigm to visually display the research.

**CONSTRUCTION TECHNOLOGY**

Throughout the ages humans have demonstrated a compulsiveness for building bigger, more elaborate, better structures. Construction is a complex system requiring a variety of skills, knowledge of materials and processes, and extensive planning and design based on a thorough understanding of building codes and standards.

The variety of construction projects, e.g., residential, commercial, highway, pipelines, and dams, are part of a technical system to improve the quality of human condition. A study of Construction would be incomplete without attention given to the technological impact on the human condition. Examples of technical and technological concepts included in the study of Construction are listed in Figure 6-6.
THE CONSTRUCTION SYSTEM

TECHNICAL

ADVANCED SKILL DEVELOPMENT AND IN DEPTH STUDY OF MATERIALS AND PROCESSES FOR CONSTRUCTION.

MACHINE CONSTRUCTION PROCESSES
STANDARDS SPECIFICATIONS SEPARATING HOLE PRODUCING JOINING SHAPING FASTENING FINISHING MAINTAINING TOOLS AND EQUIPMENT

SURVEY OF MATERIALS & PROCESSES
INTRO. TO MATERIALS CLASSIFICATION IDENTIFICATION CHARACTERISTICS PROPERTIES STRUCTURE EXTRACTION COMPOSITION ORIGIN CONVERSION STANDARDS TESTING

CONSTRUCTION FABRICATION PROCESSES WORKING DRAWINGS SPECIFICATIONS CODES FOOTINGS & FOUNDATIONS FRAMING ROOF SYSTEM ELECTRICAL SYSTEM PLUMBING INTERIOR FINISHING

LEVEL II

ECOLOGICAL IMPACT SOCIAL IMPACT HISTORICAL HERITAGE CAREER INFORMATION HUMAN RESOURCES TECHNOLOGICAL ASSESSMENT TECHNOLOGICAL TRANSFER LAND UTILIZATION RECLAMATION REFORESTATION ENERGY UTILIZATION ALTERNATIVE HOUSING

LEVEL I

IDENTIFICATION LAYOUT FORMING COMBINING CONDITIONING FINISHING

INTRO. TO PROCESSES MEASURING
Construction Level I. Level I activities for construction are the same as those for manufacturing. See Figure 6-7 (p. 190). The purpose of both systems is to provide a basic understanding of industrial materials and processes. Some examples of how Level I courses can serve as an introduction to both systems may be appropriate at this point.

Suggested Level I lab activities are as follows:

A study of wood could include a discussion of the methods used to harvest both softwoods and hardwoods, transform them to standard shapes and sizes, and identification of appropriate uses of each for construction and manufacturing.

Laboratory activities are designed to introduce students to materials and processes in industry. Among those concepts are measurement and layout. Activities directly related to Construction would be assignments requiring the use of sliding t-bevels, framing squares, and tape measures. An appropriate assignment would be to require a student to determine the length of a common rafter using the tables on the framing square and layout the rafter for a given roof pitch.

Suggested Level I classroom activities are as follows:

1. A discussion of organizations that set standards for grading softwoods and hardwoods naturally leads into a description of where different grades are used in construction and manufacturing. An example activity illustrates this point.

Divide the class in two groups. Assign hardwood standards and classifications to one group and softwood standards and classifications to the other. Their task is to identify organizations that establish standards for each lumber classification, describe the standards and use classification for each, and secure samples to share.

Use classifications for softwoods (Yard, Structural and Factory and Shop) are established according to their applications as they relate to construction and general building needs. A thorough discussion of where they are used in construction is an excellent method of introducing students to terminology in residential construction.

While it appears that these activities are commonly used in traditional programs, it is important to remember that they are small elements of a total approach. Traditionally, these activities are introduced in very narrow curricular areas, i.e., woodworking, metalworking, plastics, etc.

Technology Education at Level I emphasizes the conceptual approach. Measurement, as a concept, is taught first and then the activi-
ties are introduced to demonstrate how it is applied to various processes and with different materials.

Construction Level II. Level II activities are designed to increase the student's knowledge of how materials and processes are used in a logical and sequential fashion to produce a structure. Students should apply these principles and increase skill development in this area.

Assign students the task of demonstrating the effectiveness of a passive solar design. The students will consider the following variables in completing this assignment:

- Investment Cost
- Thermal Efficiency
- Aesthetic Design

The vehicle for studying the above factors will be a full scale module built to student designed/faculty approved specifications. The finished module will be placed outside, given a southern orientation and tested for thermal efficiency.

The passive solar module will be tested under the following conditions:

- Heat storage mode
- Heat distribution from storage
- Heat distribution without storage
- Exhaust with shade
- Exhaust without shade
- Night-time heat retention

While the primary objective is to study solar energy effectiveness, many other skills and knowledge related to construction and planning are introduced.

Although various modules have been used in construction activities, an excellent approach from an educational perspective is a full scale, partial house module, with three exterior sides and one interior wall. This module permits the use of various exterior and interior materials and two roof structures. The important aspect of this project is that goals remain educational, not economical.

Construct a scale model suspension bridge. Calculate loads and strength requirements prior to actual construction. This activity should introduce surveying and materials testing. Compression and slump tests could be conducted for concrete and tensile tests on cable. The objective is to construct a structurally sound project.
Suggested Level II classroom activities are as follows:

1. Using prepared blueprints and specifications, complete a cost estimate for a residential structure. The cost estimate should be prepared on standard forms and follow the natural order of construction i.e., foundation, framing, wiring, etc.

2. Develop a schedule for the construction of a suspension bridge. Industry standards should be used for this activity, e.g., CPM or PERT. Require students to develop networks and use microcomputers to calculate completion time and probabilities.

MANUFACTURING TECHNOLOGY

Manufacturing is the intentional act of making something useful from raw materials by hand or with machinery. An intentional act implies that planning preceded the activity and there is an organized procedure for accomplishing the conversion of raw materials (inputs) to products (outputs). Given this definition, it becomes obvious that students of manufacturing must study the materials, processes, and the systematic and logical sequence of manufacturing operations in the conversion of raw materials to products.

A thorough knowledge of these concepts would make the individual technologically literate in manufacturing. Technical literacy in an ever-changing, and sometimes threatening, environment is simply not enough. A study of manufacturing must include a study of the multi-dimensional relationships between humans and technical systems. This includes a study of the past, present, and potential future social and cultural impacts of the conversion of raw materials to products.

In manufacturing technology, knowing why becomes as important as knowing how. While the major emphasis of a traditional industrial arts curriculum is task or job analysis (knowing how), the technology-based curriculum combines basic scientific principles and theories (knowing why) with a study of contemporary manufacturing processes (knowing how).

Manufacturing Level I. Level I activities provide students with a basic understanding of industrial materials and manufacturing processes used in contemporary industry. The purpose is to provide a technical understanding of the nature and behavior of materials and how properties and characteristics influence the conversion of raw materials. It is essential that students grasp the importance, limitations, the potential of materials and be able to match the material with product and
process requirements. Major emphasis is placed on identification, properties, characteristics, and applications. Typical properties include density, porosity, tension, compression, elasticity, ductility, hardness, conductivity and other physical, mechanical, thermal, chemical and electrical properties.

Classifications are also important in structuring the study of materials. Several simple classification schemes are used by material scientists: metallic and nonmetallic is one example. Another is metals, ceramics, and polymers. One approach is to study properties and characteristics for each material classification. However, it is beneficial to compare properties of one material with another. For example, comparing polymers with metals for electrical properties could demonstrate why copper is a conductor and polyvinylchloride is an insulator.

Once a basic comprehension of materials is achieved, students understand why properties and characteristics of a material determine the manufacturing process. For example, if a student understands the iron-iron carbide diagram and the relationship between carbon content and hardenability, an explanation of why iron is cast and steel forged becomes more relevant.

Processes in the laboratory should include measurement and layout, forming, separating, combining, conditioning, and finishing. Students are provided with information and demonstrations related to processing various materials. Underlying concepts and principles from physical science are often identical, regardless of the material being processed. For example, the basic concept of separating by a chip removal process is generally the same for both metals and nonmetals. Separation occurs as a result of force applied to the material that is greater than resistance to that force. The principles of feed, cutting speed, and depth of cut are applicable to all materials.

Forming by extrusion is another example of a manufacturing process to shape metallic and nonmetallic materials. A final example is molding, also used in forming metal, wood, plastic and ceramic parts. A study of manufacturing that emphasizes processes and their fundamental principles provides the student with greater breadth, and if properly presented, a greater understanding of scientific concepts and principles that provide the foundation for transforming any material.

Suggested Level I lab activities are as follows:

1. After a discussion of the properties and nature of various species of woods, require students to match the descriptions of each of ten samples of hardwoods and softwoods to samples provided. Descriptions should include grain texture, pattern, cell structure, appearance of growth rings, specific gravity, color, and aroma.
THE MANUFACTURING SYSTEM

LEVEL I

INTRO. TO MATERIALS
CLASSIFICATION
IDENTIFICATION
CHARACTERISTICS
PROPERTIES
STRUCTURE
EXTRACTION
COMPOSITION
ORIGIN
CONVERTING
STANDARDS
TESTING

INTRO. TO PROCESSES
MEASURING
LAYOUT
FORMING
COMBINING
CONDITIONING
FINISHING

LEVEL II

ADVANCED SKILL DEVELOPMENT AND IN-DEPTH STUDY
OF MATERIALS AND PROCESSES FOR MANUFACTURING.
MFG. FABRICATION PROCESSES
DESIGN
LAYOUT
CUTTING & SHEARING
FORMING & BENDING
FASTENING
CONDITIONING
FINISHING
MFG. MACHINE PROCESSES
CASTING
MEASUREMENT
LAYOUT
SET-UP
CUTTING ACTION
SPEEDS / FEEDS
STOCK CUTOFF
MECHANICAL MACHINING
MACHINE CONTROL
ELECTRICAL EROSION
CONTROLLED MELTING
CHEMICAL EROSION

ECOLOGICAL IMPACT
SOCIAL IMPACT
HISTORICAL HERITAGE
HUMAN RESOURCES
ECONOMICS
TECHNOLOGICAL ASSESSMENT
TECHNOLOGICAL TRANSFER
ENERGY UTILIZATION

SURVEY OF MATERIALS AND PROCESSES:

INTRO. TO MATERIALS
CLASSIFICATION
IDENTIFICATION
CHARACTERISTICS
PROPERTIES
STRUCTURE
EXTRACTION
COMPOSITION
ORIGIN
CONVERTING
STANDARDS
TESTING

INTRO. TO PROCESSES
MEASURING
LAYOUT
FORMING
COMBINING
CONDITIONING
FINISHING

Figure 6.7: The manufacturing systems model illustrates the progression of content through Levels I and II.
2. Require the use of microscopes to view an end grain sample to determine the arrangement of cells in the growth rings. Specific gravities of each sample should be determined using appropriate formulae. All data should be recorded on prepared forms.

3. Using ASTM standards, prepare a 505 specimen from a piece of 1020 hot rolled steel. Indent a 2" gage length in the specimen. Place specimen in jaws of tensile testing equipment, observe and record load deformation data. Measure and record gage length and diameter at reduced section of break. Compute and record breaking strength, percentage of elongation, and percentage area of reduction. Several variations of this type of activity can be introduced to demonstrate the properties of metal and nonmetals. For example, percentage elongation can be compared among aluminum, mild steel, plastic, and reinforced plastic.

An appropriate activity is to incorporate several manufacturing processes (separating, hot and cold forming, combining, conditioning and finishing) in the design of a semester project. Most products incorporate multiple materials and processes. This approach would compare favorably with current industrial practice. It is often difficult to incorporate all materials and processes into one product. Activities in addition to the project may be needed to demonstrate appropriate processes. Activities in Level I should be directed toward "knowing why" as much as "knowing how." A discussion of classification, origin, characteristics, properties, and structure of materials for metallic and nonmetallic materials should precede lab activities.

Suggested Level I classroom activities are as follows:

1. Provide students with a description of a product with detailed specifications regarding physical, thermal, mechanical, and electrical properties. The objective for students would be to identify the best materials for the product.

2. Have each student submit a brief paper on a specific material within a classification. They should provide information related to the source of raw materials, location, availability, and method of converting to primary materials.

Manufacturing Level II. Level II activities provide students with advanced study of tools, materials, machines, and processes used by industry to transform raw materials. No emphasis should be placed on duplicating specific tasks or skills required by the machinist or cabinetmaker. Their roles are constantly changing with the introduction of new materials and processes. However, the basic principles remain
constant, i.e., theories and processes critical to accomplishing the conversion of raw materials (inputs) to products (outputs). These principles provide the framework for the study of Level II manufacturing.

The basic principles and concepts should be incorporated into the curriculum. Figure 6-7 illustrates the concepts organized under Manufacturing Machine Processes and Manufacturing Fabrication Processes. Level II problems become more difficult, are designed to increase skills with various processes, and develop a greater understanding of properties and characteristics of materials.

Suggested Level II lab activities are as follows:

1. Have students design and produce a mold for one of the plastics processes available, e.g., compression or injection molding. This could involve both electrical discharge machining (EDM) operations (a non-traditional machining process) and computer numerical controlled (CNC) equipment if available. Require students to write programs to produce a desired design in an electrode to shape the mold through the EDM process. This activity requires a great deal of problem-solving and exposure to a number of traditional and non-traditional processing principles.

2. It is important for students to realize that many of today's finished goods are fabricated from several materials. Have students submit rough sketches, final assembly, and detailed drawings of a student selected, faculty approved project. The project must meet the following criteria:
   A. Consist of multiple materials including, but not limited to metal, reinforced plastics, and wood.
   B. Incorporate all of the following processes:
      - Cutting and Shearing
      - Hot Forming
      - Cold Forming
      - Cohesion
      - Conditioning
      - Mechanical Fastening
      - Finishing

Suggested Level II Classroom activities are as follows:

1. Discuss traditional and non-traditional manufacturing machine processes in class. Have student select a state-of-the-art process (laser, ECM, plasma arc, etc.) and compare it with a traditional process. Have students discuss the ba-
sic principles of the process and compare efficiency, economics, versatility, training, other pertinent information. A discussion of how the new technology has impacted the nature of work in the manufacturing industries should be included.

2. Discuss the machine tool industry from historical perspective and emphasize its impact on the concept of mass production and interchangeability of parts. A follow-up would be a small group activity involving a project mass produced from several parts. Emphasis would be on standardization and interchangeability of parts. Materials should not be limited to metal.

3. Discuss various technical aspects of Production including, but not limited to, batch manufacturing, mass production, product flow, PERT, CPM, robotics, economics, etc.

**TRANSPORTATION TECHNOLOGY**

Transportation is accepted as one of the four universal technical adaptive systems found in all cultures. Of the four systems (Manufacturing, Construction, Transportation and Communication), transportation is probably the least understood and least accepted by teachers in terms of developing and implementing curriculum in their classroom.

But it should not be so! In our culture, we are constantly confronted with some aspect of transportation. We drive cars and trucks, ride bicycles, take the bus or train, fly to all parts of the world, haul groceries, garbage, grain, gas, oil, parts, pieces, materials, dirt, and frisbees from place to place. In addition, attempts at streamlining manufacturing and construction operations have caused an increased emphasis in the study of transportation. New systems are being designed to transport raw materials, pieces, parts, sub-assemblies, and finished products within the confines of the plant. Transporting goods to the construction site and the movement of those goods on-site has taken on renewed importance with the potential effects on the profit margin. Finally, the movement of materials via stationary means often causes international (societal) concern, e.g., the Alaskan Pipeline.

Transportation Level I. The purpose of this level is to familiarize the beginning student with the movement of people or goods. Introductory information concerning energy, power sources, propulsion, the application of primary scientific principles, and the social considerations of transportation should be included.
### The Transportation System

#### Level II
- Alternative Energy Systems
- Hydraulics and Pneumatics
- Engine Systems
- Electrical and Chemical Power
- Industrial Material Handling
- Construction Site Material Handling
- Transportation Design

#### Level I
- Industrial Mechanics
- Power Transmission
- Energy Conservation
- Energy Conversion
- Power Systems
- Basic Electricity

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**Figure 6-8. The transportation system model illustrates the progression of content through Levels I and II.**

**Suggested Level I lab activities are as follows:**

1. Working individually, students should conduct experiments with the "simple machines" to determine their function, limitations, and mechanical advantage. Examples include working with fixed and moveable pulleys; determining friction (rolling vs. sliding); identifying relationships between movement and force on the inclined plane; comparing first, second, and third class levers. These experiments should be set up and completed in the laboratory.

2. Working in small groups, develop and build a 4' x 4' futuristic model community that does not allow any private owned vehicles. The community should contain at least one major healthcare facility, one industry, and one major shopping area. Other considerations should include areas for leisure activities, governmental agencies (fire, police, etc.), and senior citizen facilities.

**Suggested Level I classroom activities are as follows:**

1. Conduct research to find the origin of the "simple machines," e.g., pulley, level, wheel, screw, and inclined plane. Identify the application of these in products manufactured today. Limit areas of study to one of the types of transportation including terrestrial, marine, air, and space.
2. Plan a material handling system for manufacturing a simple product using a simulated production line. Determine types of material handling devices including, but not limited to, conveyors, crane or hoist, robots, and automated guided systems.

*Transportation Level II.* After successful completion of Level I, the student should have developed a solid knowledge base and an understanding of the scientific principles involved in Transportation. Level II activities are supportive of that knowledge base in that the student will apply these principles to higher order problem-solving applications.

Suggested Level II lab activities are as follows:

1. As an individual project, students should design and build an automated material moving device. Suggested criteria include (a) must be capable of moving a 2 pound weight a distance of 3 feet horizontally and 3 feet vertically, (b) object must come to a complete stop, (c) students are allowed one manual movement to start the automation, and (d) no limit on types of materials. Using a spring device, measure the amount of force required to move the object. Continue with calculations of work produced. Have students present engineering principles incorporated into their design. Compare designs with each other.

2. Working with a production class, (see Capstone section) use a Computer Aided Manufacturing (CAM) program to plan the product flow during manufacture, i.e., move two quarts of water from point A to point B — (fifty feet apart). Design the actual manufacturing facility, including equipment placement and material handling needs, according to the data produced from the program.

Suggested Level II classroom activities are as follows:

1. Assuming the role of a Transportation Supervisor within a fictitious company, develop a plan for shipping limited quantities of small items across the nation. Design a graphic presentation comparing costs, routes, and time.

2. Conduct traffic counts to determine traffic density in a given area. Compare actual counts with traffic density data available from state Departments of Transportation. Determine and report needs for implementing some type of mass transit system including societal effects and potential changes in the environment, e.g., less pollution, etc.
Level III activities are designed to meet two critical objectives of the total educational process. These objectives are to:

- Develop insights into the fundamental aspects of industry and the technological achievements made by industrialized societies; and
- Develop an understanding of the principles of investigation applied to the solution of industrial research problems.

These objectives are met in a technology-based curriculum through carefully planned Level III classroom and laboratory activities. Wright (Note 3) described the type of capstone experience to meet the first objective. The capstone approach requires the knowledge and skills of students who have completed Level I and II. The incorporation of skills and knowledge in the capstone experience is described as follows:

All production enterprises use a variety of interrelated systems to make the company or corporation successful. The product is developed and produced using a materials processing system. Ideas and important messages are exchanged using a communication system. Product flow in the plant and distribution outside the plant depends on a transportation system. Each of these systems are interrelated and interdependent on each other in an enterprise and therefore can be called the production systems (p. 8).

Students concentrating in each of the respective technical systems should use their particular skills and knowledge in the complex problem of organizing and successfully operating an enterprise. Role playing becomes an important part of the total process because of the career awareness aspect provided through this activity.

Research, development, and experimentation are areas in technology that received little attention in the past. The profession has been cautious in moving from an educational foundation based on job or task analysis to one well grounded in the laws and theory of science and mathematics. In-depth research, laboratory experimentation, and/or development of a student selected and faculty approved topic in one of the technical systems allows students the opportunity to further develop problem solving abilities. At the same time, the process enhances their knowledge and skill in a technical concentration.

For example, consider an activity on recycling materials. The purpose of this activity is to examine the potential for the recycling of aluminum cans. The waste problem in our world is so vast, that we will limit
our investigation to the aluminum can. This product was selected due to its popularity and the emphasis being placed upon it for recycling. This activity will allow technology students to actively participate in conserving energy and exploring environmental concerns.

Our society continues to look for ways of conserving non-renewable energy resources. The United States, which makes up around five percent of the world's population, consumes nearly one-third of all resources extracted from the world. Our metals are a depletable resource. As they become scattered across the globe as a result of being sold, used, and disposed of, they become lost from an economic point of view. This process cannot be stopped, but we can slow the process down with an effective recycling program.

**The Capstone Activity**

Develop a typical corporate organizational structure and assign students to a functional department according to their particular area of expertise, e.g. marketing, research, product engineering, process engineering, quality control. The corporation will write contracts, issue stock, design the product, build the prototype, create inventory control systems, develop materials handling systems, design the production line, produce the products, and deliver them to stockholders.
Research, Development and Experimentation

Students will identify a narrow area of interest in their particular concentration. They will develop a proposal including a problem statement, statement of methodology, and literature review. The methodology must include applied laboratory research and may require students to search for sources of materials and design equipment necessary to aid in the completion of their problem statement. Examples of potential areas of research are:

- Material and Structural Testing
- Composite Materials
- Alternative Energy Systems
- Automated Machine Control
- Robotics
- Computer Graphics
- Four Color Separation

ADAPTING FACILITIES TO CURRICULUM

Traditional facility design, i.e., the unit shop containing only woodworking, metalworking, or graphic arts equipment has hampered the process of change. Frequently, curriculum developers have disregarded existing equipment placement with little thought given to reorganization as part of a comprehensive curriculum plan. Curriculum planning should not be controlled by facility constraints. After educational objectives are in place, the facility equipment, and all other ancillary materials should be considered in the curriculum plan.

There is little chance of obtaining major funding for construction of new facilities with current economic trends and projected decreasing enrollments. Although this is a constraint while planning curriculum, it cannot be the primary consideration. Facilities must be considered, but a significant compromise of the curriculum to fit existing facilities is not necessary.

We must be cognizant of changes in our technical world and incorporate them into the existing curriculum. Therefore, facilities should be planned to accommodate future changes. DeVore and Lauda (1976) indicated that "...unit laboratories must give way to open-spaced concepts which allow for flexibility in a variety of learning situations." (p. 152). Bender (1978) expands this concept to include not only flexi-
bility, but also adaptability. Bender defines adaptability as "...the ease with which space designed for a given function can be transformed to accommodate changes in methodology, instructional equipment, content, and the like." He defines flexibility as "...the change quality of a physical facility which permits variation in the learning activities, scheduling class size... (p. 5)."

The criteria of flexibility and adaptability are important considerations during curriculum planning. There is no need for permanence in most equipment placement. Precision equipment is often moved each time a production line is set up without apparent damage. Flexible facilities in which equipment placement is not considered permanent will actually enhance the curriculum planning by allowing a larger number of content options.

If any curriculum is to remain contemporary, the need for flexible and adaptable facilities is apparent. This was emphasized during the attempts to develop a national curriculum during the 1950's and 60's. Maley (1979), in referring to the Maryland Plan, stated that, "Some rearrangement of laboratories to provide the necessary kinds of (learning) environment was needed..." (p. 140). Lux (1979) adds credence to this idea in his statement concerning the Industrial Arts Curriculum Project when he indicated that here is a "...lack of appropriate laboratories, facilities and equipment...Flexible, industry-like laboratories were the exception (p. 155)."

Utilizing large, open facilities designed in a manner that will simulate industry and the "real world" should provide pre-service teachers with a broader range of knowledge. These undergraduates will continue to need technical skills in the 1980's and 90's as in the past. To teach these skills, we must provide students with working environments that promote learning.

Teacher educators should emphasize the importance of the physical facility to our undergraduates. Facilities are expensive and time consuming to maintain, but this aspect of discipline, the tools and materials, makes us unique and able to stand apart from other educational programs. Often, it is the "tools and materials" aspect of the program that can initially interest students.

We must never allow our facilities to be eliminated because we believe that skill development is an important part of our curriculum. Changing any curriculum to a technology-based approach does not in any way promote the elimination of facilities. However, a technology-based curriculum should cause more efficient use of existing facilities. Often, this increased efficiency will result in lower overall costs. With careful planning, curriculum developers are able to "do more with less."
REFERENCES


Lux, D.G. The development of selected contemporary industrial arts programs: The industrial arts curriculum project. Industrial Arts Education: Retrospect, Prospect, 18th Yearbook, 1979, p. 155.


REFERENCE NOTES


During the past 100 years graduate programs in Industrial Education have provided an opportunity for personal growth and professional development through a variety of degrees. The most commonly used degrees for industrial graduate education are:

- Master of Science (MS)
- Master of Arts (MA)
- Master of Education (M Ed.)
- Education Specialist Degree (Ed.S.)
- Certificate of Advanced Graduate Study (CAGS)
- Doctor of Education (Ed.D)
- Doctor of Philosophy (Ph.D.)
- Doctor of Industrial Technology (D.I.T.)

In 1984, one hundred seventy-eight of the two hundred fifty-five colleges or universities offered master’s degrees, twenty offered a Specialist degree, twenty-nine offered a Doctor of Education degree, twenty-seven offered a Doctor of Philosophy degree, and one offered a Doctor of Industrial Technology degree (Dennis, p. 4-90, 1984). This reflects a slight decrease compared to a study by Jenks (1979) who reported similar data in his thesis at Eastern Illinois University. As the profession transcends from an emphasis on industry to technology, several questions are appropriate for a chapter on graduate education:

1. Why has there not been growth in the number of institutions that offer graduate degrees?
2. What are the differences between the degrees?
3. What are the impacts of graduate programs for Industrial Education?
4. Would a shift in content base from industry to technology change the purpose of graduate education?
5. What would a technology education program look like at the master’s, specialist, and doctorate levels?
GROWTH OF GRADUATE PROGRAMS

With the exception of a few states which require the master's degree, the bachelors and doctorate are the only degrees used as requisites for employment. The bachelor degree is an entry requirement for certification and employment in the public school and the doctorate is increasingly becoming the entry requirement for employment in College/University teacher education. Again, with some exceptions, tenure and promotion are held back to those teacher educators who do not have the terminal degree.

With these increasing requirements one would think that graduate programs are bursting at their seams, yet they are not. A cursory review of the production data for graduate degrees shows that most programs are either status quo or experiencing a slight decrease in enrollment. In addition, only one college has indicated the development of a new master's program since 1979. Yet, the total is down by one (177) reflecting a new loss of two graduate programs during the past five years (Dennis, p. 4-90, 1984).

The decline in graduate education may be reflective of the decline of undergraduate students in industrial arts across the nation. Poor starting salaries, lack of positions (in some areas), low prestige, and a brain drain by the more lucrative industrial technology programs appear to be the major factors affecting undergraduate enrollment. The brain drain affects the graduate program by reducing the pool of qualified potential students who would seek higher education in a teaching field. Industrial technology bachelor of science students generally are not expected to pursue the master's degree by their employers at this time.

All of these factors reflect a graduate program status quo enrollment situation and this trend can be expected to continue for industrial arts until the public school situation changes and creates new demands. However, graduate education does play an important role in the industrial arts profession. More and more teachers are seeing graduate study as a way to update knowledge or skills, qualify for promotion or tenure, move from public school teaching into community college or university teaching, gain appointment to an administrative post, or prepare for further advanced graduate study (Wright, p. 8, 1984).

DEGREE EMPHASIS

Buffer addressed the issue of degree emphasis in his chapter entitled Graduate Education in Industrial Arts (pp. 290-326, 1979). The MA and MS degrees are usually considered research degrees and can
be expected to culminate with a thesis or field study. Practice-oriented degrees such as the M.Ed., M.F.A. or M.B.A. are designed to advance knowledge for application and typically have a technical component, and or written/oral exit examination. Combinations within all of the master's degrees occurs and results in confusion within the profession concerning the purpose of each particular degree.

The Ed.S. and CAGS are advanced graduate degrees which also meet a variety of needs. The most common emphasis for these degrees seems to be in the area of administration or supervision of industrial education programs. Both the master's and specialist degrees have been used widely for entry into the Community College teaching profession.

Of greater concern more recently has been the goal of the doctoral degree programs. Traditionally, the Ph.D. is centered on research while the Ed.D. is more practice oriented. The distinction between both degrees today is much less clear with research and practice being components of both degrees (Buffer pp. 301-312, 1979).

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**Figure 7-1.** This figure represents the degree emphasis of popular graduate degrees.
Recently, an alternative to the Ph.D. and Ed.D. has been developed at the University of Northern Iowa. The Doctor of Industrial Technology is designed to be both a research and practice degree for industrial arts teachers and industrial technology majors (White, pp. 7-11, 1983). The unique internship required of this new degree makes advanced specialization in Industrial Technology an integral part of the student doctoral program/experience.

**IMPACT OF GRADUATE PROGRAMS**

The blending of degree objectives has caused some concern for those who are knowledge seekers as well as those who are knowledge users. Moss has made a point concerning the ability/credibility of doctoral students who are expected to conduct original knowledge-producing research. His position is that they are not properly prepared to conduct scholarly research and, therefore, the research goal of doctoral study should be de-emphasized (p. 398, 1975). Lux, on the other hand, argues that the content or core may not be as important as the process of graduate education. Lux’s position is centered around flexibility for program design which has the ability to develop each student to their fullest potential (p. 397, 1975).

When practitioners were asked to identify the top ranking doctoral degree granting institutions in the nation, their response was not based on research production (Koble, pp. 10-14, 1980). Instead, such criteria as reputation of faculty, program, and graduates were used to judge the ranking of each program. In fact, two of the lower ranking universities had larger research libraries than those who ranked in the top five, (Koble, p. 16, 1980).

The apparent decline in the emphasis and capability of research at both the master’s and doctorate level has serious implications for a profession which appears to be transcending from an industrial orientation to a technology education curriculum. Traditionally, the major doctoral granting universities have provided curriculum research and direction for the profession. Faculty members working with master’s and doctoral students have created knowledge pools, taxonomies, field studies, and philosophical rationale for Industrial Arts over the years! Graduates of these programs promoted and applied the university research at the teacher education level which, in turn, transmitted it to application in the public school. This “trickle down” process is paramount to the survival of Industrial Arts/Technology Education, if we are to keep up with the technology and meet the needs of our students in the future.
CONTENT SHIFT IMPACT FOR GRADUATE EDUCATION

The present shift from an industry to a technology content base will have tremendous ramifications for graduate programs. Research and field testing will need to be re-emphasized to build on the knowledge base developed by people and programs mentioned by Lauda and McCrory in Chapter I. In addition, administrators and public school teachers will need to be inserviced concerning the rationale and philosophy of Technology Education. Empirical research results will need to be further developed and communicated to a profession traditionally reluctant to change quickly.

Leadership from those institutions promoting, researching, or transitioning into Technology Education will be critical during the next decade. If we are able to visualize this transition as being similar to the change from manual arts to industrial arts, then we must be careful not to make the same mistakes for adoption and implementation. Graduate programs, both practice and research oriented, can make a significant contribution in this process, but they will need to reorganize, revise, and revive to meet the challenge.

TECHNOLOGY EDUCATION GRADUATE PROGRAMS

The primary difference between Industrial Arts and Technology Education is in the adoption of a new content reservoir. Developing curriculum and activities from the content base of technology creates several new objectives for the technology education profession. Maley has best summarized the basic goals of a technology education program in his article “Perspectives on the Future.” These goals are also appropriate at the graduate level using a variety of approaches:

MASTER'S DEGREES

A common question raised in the literature about technology education graduate study centers around the content base for the master's degree. The old argument represents a dichotomy between technical/practical and technical/philosophical emphasis.

According to Swanson, “...the notion that the undergraduate degree is more heavily weighted in technical than the professional and that the master’s degree is inverted, seems sound. Any master's degree program allowing over 25 percent of technical work should question its goals (1974, p. 50)."
### TABLE 7-1

**SUGGESTED GUIDELINES FOR GRADUATE PROGRAMS**

1. The program should focus on technological alternatives in dealing with the identifiable problems of mankind.
2. The program should provide insights into and more effective use of leisure time.
3. The program should make extensive use of community resources.
4. The program should provide for extensive and effective involvement in community and societal problems.
5. The substance of the program should promote the development of innovation, problem solving, and speculation.
6. The program should be based upon a living-learning involvement with the current and future issues facing mankind.
7. The program should be directed toward the total population and at all levels in education.
8. The program should be directed toward the wise use of technology.
9. The program should be multidisciplinary in its approach to problems and issues.
10. The program should place considerable stress on the development of the learning processes.
11. The program should be rooted in the human needs of a dynamic, fast-changing society.
12. The program activities, content, and processes should be based upon the learning and growth needs of the individual served.

[Maley, 1980, pp. 10-32]

Others question the value of graduate study which appears to be an extension of undergraduate technical skill development. According to Jenks, seventeen schools offer a master’s degree made up of only technical instruction, (1979, p. 39). Most schools use a broad approach and combination of technology, philosophy, and supervision. Gaining popularity, sixteen schools are now using a technology-base and twenty-seven schools reported their content to be centered around the concept of Industrial Technology. Correspondingly, less schools (27) now base their graduate programs on the study of “industry” per se. (Jenks, 1979, p. 39)

Because the shift in content requires both technical and technological literacy (Wright, 1980), the master’s degree should be developed with two major cores, one technical and one technological.
The technological core is designed to provide students with a general background about the characteristics of technology and its effects on humankind. It also provides an opportunity for students to develop research skills, dialogue techniques, synthesis, and analysis methodology for technologically related problems. The following example of a technological core has been implemented at Eastern Illinois University with positive response since 1977 (Lauda & Wright, pp. 25-30, 1983).

A readings course is used to get the students into the literature (similar to the type of books and articles recommended by Maley's article) about general issues and problems related to technology. It also serves as the basic research course with emphasis on research techniques, writing styles, publication, documentation, and presentation of applied research. Students keep weekly dialogue-aid sheets to help them debate topics during class. Analysis is practiced by having each student present
the views of several writers on a common topic and provide the class with a summary of major issues. Finally, a scholarly paper is developed that incorporates many new techniques learned during the semester. Students are able to discuss the behavior of technology and its effects on society, research, synthesize and analyze information, and express their views in a scholarly manner through writing. In addition, students are able to build a base for developing technology education curricula using the information reservoir of technology.

Two technical information courses make up the remainder of the technological core. One course, Technical Developments in Technology, covers an historical perspective of major technical developments in the areas of communication, energy/transportation and production. Each student investigates a technical area to identify developments that have rendered others obsolete or have occurred as a prerequisite for new development. They plot the information on a timeline and report their progress to the class. Working models are individually developed by students and represent a type of technology used in the past.

Content for the course is based on general issues related to how humankind has moved from an agrarian society to a highly technological society and the major developments along the way. Students gain insight into the heritage of their "technical bags," share the information with each other, and become more aware of how humankind has depended on technology in the past.

The counterpart to Technical Developments is Contemporary Problems in Technology. This course requires students to investigate the same "technical bag" using resources developed during the previous twelve months. The information is gathered and plotted on an interface paradigm that shows how the technical areas are interrelated. Technological assessment and forecasting techniques are taught in this class and each student is required to run a delphi or trend extrapolation in order to project what will be happening in their technical areas during the next 25 years. Finally, students are grouped by interest areas and write future scenarios about developments in energy/transportation, communication, and production.

Content for this course is based on timely topics, e.g., energy, population, arms race, etc., dealing with contemporary technology and its effects on the global village and people affected. Students learn about new technical information, make projections about the future, and learn new techniques to enable them to get data on demand. This is an important asset in a rapidly changing technological world.

The technological core opens the door to the investigation of our technological world, its past, present, and future. The core serves as the base for programs designed to get at the issues in a technological society.
TECHNICAL CORE

The technical core is designed to update laboratory skills using the latest equipment, technology and curriculum design. For example, the course in Communication Technology focuses on the concept of image generation and reproduction. Using drafting, television, radio, printing, and photography as communication processes, each student studies the latest technology and designs simulations that can be used in the public school laboratory. Teaching units and lessons are designed and tested in class along with supportive visuals and teaching aids. Common problems are shared about facilities, equipment, and change methodology. Strategies are discussed on how to implement a technology education curriculum which focuses on the technical and technological aspects of communication.

Production technology focuses on materials processing, manufacturing, and construction techniques. Modern computer-aided equipment is used to show how flex-manufacturing and construction are being used by industry. New materials, finishes, and technical processes are discussed with ideas on how to simulate the newer technologies in the school laboratory. Curriculum designs, units of study, lesson plans, and teaching aids are designed and tested in class. Strategies for change are planned with tips on converting programs to Technology Education.

The Energy/Transportation course focuses on the electromechanical system used in industry today. The latest electronics and mechanics technology are studied including applications for robotics, transport systems, and alternative energy resources. Basic programming and guidance and control systems are studied to provide updated background for teaching this area in the public school. Energy and transportation simulations are designed and tested with the development of teaching units, lesson plans, and visual aids. Change strategies for converting traditional curriculum fare to Technology Education are discussed in class.

ELECTIVE OPTIONS

At least three options can be designed in the master’s program based on the goals of the student. These are as follows:
Figure 7-3. There are three options used in a technology education masters degree program.

Research. Usually the research oriented student will be working for the MS or MA degree and may wish to continue his/her education for advanced graduate study. A typical option for research might look like this:

- Statistics: 2 hrs.
- Research Methods: 3 hrs.
- Operations Research: 3 hrs.
- Technology Core: 18 hrs.
- Total: 32 hrs.

Supervision. For the M.Ed. student who may want to move into technology education supervision as the department head, Coordinator, or Director, a typical option might look like this:

- Facility Design: 3 hrs.
- Admin/Supervision: 3 hrs.
- Curriculum Development: 3 hrs.
- Computer Programming: 3 hrs.
- Personality/Motivation: 2 hrs.
Curriculum. Some students want to design curricula and instructional methodology as part of their MS.Ed., or M.Ed. master's experience. Such an option might look like this:

**Instructional Design** 3 hrs.

**Curriculum Development** 3 hrs.

**Issues and Trends in Technology Education** 3 hrs.

**Implementing Technology-based Education** 3 hrs.

**Evaluation/Test and Measurement** 2 hrs.

plus:

**Technology Core** 18 hrs.

32 hrs.

The possibility for creating various options are endless and should be based on the resources of the university. A written program or plan of study with goals, objectives, and a timetable is recommended to ensure the student is meeting his/her needs for graduate study. It is also recommended that a comprehensive oral or written exam be used toward the end of the program to ensure quality performance and provide feedback for curriculum "fine tuning."

Technology education master's programs create a great deal of excitement in the department with lively debates, innovative ideas, and unique experiences. The pilot programs being tested in several universities at this time indicate very positive experiences.

**SPECIALIST DEGREES**

The Certificate of Advanced Graduate Study and Education Specialist degree have been popular in institutions where the doctoral degree is not offered. The technology education specialist degree is focused on "change methodology" and is designed for people who are/want to be state supervisors, city-wide directors, curriculum consultants, Vocational Plan Writers/Directors, and professional change agents.

The technology core is designed to provide a perspective of technology with an emphasis on the social, cultural, and human impacts of technology.
Figure 7-4. The core for the specialist degree program focuses on the forces affecting public education today.

**Specialist Core**

The core for the technology education specialist degree focuses around the public school, its mission, goals, and objectives. As change agents and supervisors of Technology Education, it is important for the specialist degree student to know the functions of public education and the various factors which influence decision-making.

The course in public education is designed to look at the total public school operation, regulation (local, state, and federal), influences and income. The role of the school board, superintendent, principal, and supervisor is discussed in context with the mission and goals of the school district. Vocational education regulations and funding policies are studied and a short and long range plan are developed to provide a scope and sequence model for Technology Education.

Proposals for change are developed and presented to the class members who act as the school board. They include curriculum planning based on demographic data, advisory board input, school district needs, and technological trends.
Technology and Culture is an advanced readings course which is designed to get the student into contemporary literature. The focus is on synthesis, analysis, and decision-making for technologically related problems.

Change strategy is studied in a sociometrics course based on worldwide case studies. Demographics and how to use them for program design are discussed with the major topics of adoption, dissemination, innovation, and rejection. The purpose of this course is to help students gather data and plan strategies for change in the public school.

Industrial psychology is a standard course used for management majors. It applies to the specialist degree because each supervisor is faced with unique problems between management and the bargaining unit which is magnified by the introduction of new curriculum based on the study of technology.

Finally, alternative technologies is an advanced technical course designed to continue updating of technical knowledge in the areas of communication, production, and energy/transportation. Like all technology education graduate degrees, the importance of remaining current in one's technical field is paramount and basic.

**Elective Options**

The technology education specialist degree may have two basic options: one for supervision and the other for advanced technical preparation.

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**Figure 7-5.** There are two options for individuals pursuing specialist degree programs.
Supervision. A typical supervision option for the Ed.S. degree includes advanced courses that lead to a certificate or permit for public school administration. An example of this option would be:

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration and Supervision</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Collective Bargaining</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Labor Economics</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Supervision Internship</td>
<td>6 hrs</td>
</tr>
<tr>
<td>Technology Core</td>
<td>15 hrs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30 hrs</td>
</tr>
</tbody>
</table>

Technical. The technical option may be used by college/university faculty not interested in a doctorate but who want a formal degree program that will help them keep up with technology. Typically the CAGS is used for this specialist approach. Below is an example of an option in the graphics area:

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Aided Design</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Advanced Screen Processes</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Flexographics</td>
<td>3 hrs</td>
</tr>
<tr>
<td>Industrial Internship</td>
<td>6 hrs</td>
</tr>
<tr>
<td>Technology Core</td>
<td>15 hrs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30 hrs</td>
</tr>
</tbody>
</table>

As was the case with the master's degrees, a written program or study plan with goals and objectives along with a timetable is recommended. A scholarly paper or field study report could serve as the exit exam for this advanced degree.

**DOCTORAL DEGREES**

Technology education doctoral degrees are designed along the lines of original intent, one (Ph.D.) based on research, one (Ed.D.) based on practice, and one (D.I.T.) based on industrial research and practice. All three degrees are designed to be very flexible, share a common nine semester hour core, and culminate with a written dissertation.

The core is similar to the master's degree technological core but includes more in-depth analysis and advanced readings.

The history of technology is a chronological analysis of technology with implications for curriculum design, historical research, and decision-making through extrapolation. The interpretive history approach requires a series of critiques which cover the major historical divisions.
based on technological accomplishments. In addition, each student could spend a week in a major museum investigating the development of a major artifact and its effects on culture and society. The history course is designed to provide a technological and cultural heritage base to allow students the opportunity for original investigation and analysis.

Contemporary problems is a course which deals with a global view of problems caused by technology. Major problems set up in a simulation program on computer and micro-situations are analyzed for data collection and decision-making. The famous "Limits to Growth" study by Dennis Meadows is an excellent example of the type of simulations used in this class. A local, regional, state, national, or international problem may be used for the simulation.

Weekly analysis of world generation papers, magazines, and journals will be part of the problem identification process in an effort to help students visualize technology in a global context. Each week a major contemporary technology problem will be discussed in a seminar style with analysis and debate on positive and negative implications. These
sessions are "pulled" together toward the end of the semester for the assembly of a class "global report."

The readings class is designed to get students into the literature for the purpose of providing more in-depth background and improve synthesis and analysis skills. A scholarly paper is produced which is the prerequisite to the dissertation writing experience. In fact, the scholarly paper research may lead to the identification of the dissertation topic and could become part of the literature review for the dissertation proposal.

**Elective Options.** Upon completion of the core courses, the doctoral student is interviewed by a screening committee who determines if acceptance into the doctoral program is in the best interest of the student and university. At this meeting, the student identifies whether he/she will seek a research oriented or professional oriented option.

If the committee recommends positive action, the student is advanced to candidacy rank. This procedure begins the formal doctoral program with an advisor and committee format. The first task is to design a program of study which is research or professionally based. Once the program is approved by the committee, the student will begin courses selected for the option.

Figure 7-7. There are three options that student choose in a technology education doctoral program.
A sample program might look like this:

**Research. (Ph.D.)**

- Research Methods: 3 hrs.
- Statistics: 3 hrs.
- Operations Research: 3 hrs.
- Research & Development: 3 hrs.
- Seminar on Professional Writing: 3 hrs.
- Seminar on Technology & Culture: 3 hrs.
- Field Study in Technology: 6 hrs.
- Foreign Language: 6 hrs.
- Dissertation: 12 hrs.
- Free Electives: 13 hrs.
- Technology Core: 9 hrs.

Total: 64 hrs.

*The doctoral program is 64 hours beyond the master's degree.*

**Professional (Ed.D)**

- Research Methods: 3 hrs.
- Statistics: 3 hrs.
- Seminar in Professional Writing: 3 hrs.
- Curriculum Development: 3 hrs.
- Instructional Design: 3 hrs.
- History of Technology Education: 3 hrs.
- Educational Psychology: 3 hrs.
- History of Educational Thought: 3 hrs.
- Computer Programming: 3 hrs.
- Free Electives: 13 hrs.
- Dissertation: 12 hrs.
- Technology Core: 9 hrs.

Total: 64 hrs.

*The doctoral program is 64 hours beyond the master's degree.*
**Industrial Technology (D.I.T)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminars</td>
<td>4 hrs.</td>
</tr>
<tr>
<td>Research Methods in Industrial Technology</td>
<td>3 hrs.</td>
</tr>
<tr>
<td>Statistical Methods in Industrial Technology</td>
<td>3 hrs.</td>
</tr>
<tr>
<td>Fundamentals of Computer Programming</td>
<td>3 hrs.</td>
</tr>
<tr>
<td>Internship in Industrial Technology</td>
<td>6 hrs.</td>
</tr>
<tr>
<td>Dissertation</td>
<td>12 hrs.</td>
</tr>
<tr>
<td>Free Electives</td>
<td>22 hrs.</td>
</tr>
<tr>
<td>Technology Core</td>
<td>9 hrs.</td>
</tr>
</tbody>
</table>

64 hrs. Total*

*The Doctor of Industrial Technology Program is 64 semester hours beyond the master's (White, p. 10. 1983).

The review of literature for graduate study revealed several interesting points for doctoral study. Most writers agree that a research base and program flexibility are the two most important factors for successful programs. The major (and continuing) concern of the profession in general is for the continuation of leadership through outstanding doctoral programs.

The technology education doctorate should be focused on the study of technology and its implications for humankind. The Ed.D. should produce new methods for teaching technology in our public schools and universities. Field studies and curriculum development should provide empirical data used for clarifying the rationale for studying technology. The Ph.D. should produce new research which helps us understand the phenomenon of technology and related characteristics. Finally, the D.I.T. should provide a unique focus of industrial technology and new methods for increasing productivity and quality in industry and this knowledge base should be carefully analyzed by the education major to maximize the possible contribution for a technology education program.

**CONCLUSION**

Technology-based graduate study can be exciting, challenging, and make a significant contribution to the technology education profession. Several universities have developed masters and doctoral programs
with success during the past decade. The transition of the profession from an industry to a technology content base presents a number of opportunities for research, curriculum development, and leadership. These areas have traditionally been developed at the graduate level and the potential for further development is limited only by our imagination.

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