SELECTING INSTRUCTIONAL STRATEGIES FOR TECHNOLOGY EDUCATION

Editors

Kurt R. Helgeson
Anthony E. Schwaller

52nd Yearbook

Council on Technology Teacher Education

2003

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FOREWORD

The CTTE yearbook series continues to represent an important forum for sharing ideas and scholarship on topics of importance to Technology Teacher Education. Much of the success of the Council and profession is due to the kind of solid thinking and effort that are invested in the preparation of these yearbooks.

It has now been over 50 years since the first yearbook was published. The field has experienced dramatic change and growth during this time, including major shifts in the content base and focus, a name change, curriculum initiatives, standards development, and more. At the same time, there has been remarkable consistency in the attention and focus given to instructional strategies. While the content base and philosophical approaches have shifted over time, the emphasis on active, engaged, experiential learning has been very consistent.

In the 15 years since the previous yearbook on instructional strategies, considerable change has occurred in technology education. The content base has shifted from industry to technology and the field has become more closely aligned with other academic disciplines, particularly science, mathematics, and engineering. The editors of this 52nd yearbook have addressed the implications of these changes for contemporary technology education programs. A review of the 1988 yearbook demonstrates a persistent emphasis on strategies concentrating on areas such as conceptual development, social/cultural impacts, design and problem solving, and cooperative learning. While these topics remain important, changes in the profession have demanded that they be revisited. At the same time, new strategies and approaches have emerged since the 37th yearbook. As such, the editors have included chapters on inquiry, Web-based instruction, modular instruction, student competitions, and community-based experiences.

The editors, Drs. Kurt R. Helgeson and Anthony E. Schwaller, are to be commended for their insightful treatment of this important topic. The authors of the individual chapters are also to be complimented for their unique insights and perspectives. The Council also recognizes the Glencoe/McGraw-Hill publishing company for their sustained support of the yearbook series. Their commitment to the success of technology teacher education has made a significant impact on the discipline and is genuinely appreciated.

Thank you to each technology teacher educator for your commitment to instructional excellence.

Rodney L. Custer
President (2000–Present)
Council on Technology Teacher Education

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YEARBOOK PROPOSALS

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

CTTE Yearbook Committee

CTTE Yearbook Guidelines

A. **Purpose**
The CTTE Yearbook Series is intended as a vehicle for communicating major topics or issues related to technology teacher education in a structured, formal series that does not duplicate commercial textbook publishing activities.

B. **Yearbook Topic Selection Criteria**
An appropriate yearbook topic should:
1. Make a direct contribution to the understanding and improvement of technology teacher education;
2. Add to the accumulated body of knowledge of technology teacher education and to the field of technology education;
3. Not duplicate publishing activities of other professional groups;
4. Provide a balanced view of the theme and not promote a single individual's or institution's philosophy or practices;
5. Actively seek to upgrade and modernize professional practice in technology teacher education; and,
6. Lend itself to team authorship as opposed to single authorship.

Proper yearbook themes related to technology teacher education may also be structured to:
1. Discuss and critique points of view that have gained a degree of acceptance by the profession;
2. Raise controversial questions in an effort to obtain a national hearing; and,
3. Consider and evaluate a variety of seemingly conflicting trends and statements emanating from several sources.

C. **The Yearbook Proposal**
1. The yearbook proposal should provide adequate detail for the Yearbook Committee to evaluate its merits.
2. The yearbook proposal should include the following elements:
   a) Defines and describes the topic of the yearbook;
   b) Identifies the theme and describes the rationale for the theme;
   c) Identifies the need for the yearbook and the potential audience or audiences;
   d) Explains how the yearbook will advance the technology teacher education profession and technology education in general;
   e) Diagrams symbolically the intent of the yearbook;
   f) Provides an outline of the yearbook which includes:
      i) A table of contents;
      ii) A brief description of the content or purpose of each chapter;
      iii) At lease a three-level outline for each chapter;
      iv) Identification of chapter author(s) and backup authors;
      v) An estimated number of pages for each yearbook chapter; and,
      vi) An estimated number of pages for the yearbook (not to exceed 250 pages).
   g) Provides a timeline for completing the yearbook.

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

PREVIOUSLY PUBLISHED YEARBOOKS

*1. *Inventory Analysis of Industrial Arts Teacher Education Facilities, Personnel and Programs,* 1952.
*2. *Who's Who in Industrial Arts Teacher Education,* 1953.
*3. *Some Components of Current Leadership: Techniques of Selection and Guidance of Graduate Students; An Analysis of Textbook Emphases;* 1954, three studies.
*4. *Superior Practices in Industrial Arts Teacher Education,* 1955.
*5. *Problems and Issues in Industrial Arts Teacher Education,* 1956.
*6. *A Sourcebook of Reading in Education for Use in Industrial Arts and Industrial Arts Teacher Education,* 1957.
*7. *The Accreditation of Industrial Arts Teacher Education,* 1958.
*8. *Planning Industrial Arts Facilities,* 1959. Ralph K. Nair, ed.
*9. *Research in Industrial Arts Education,* 1960. Raymond Van Tassel, ed.
*10. *Graduate Study in Industrial Arts,* 1961. R. P. Norman and R. C. Bohn, eds.
*11. *Essentials of Preservice Preparation,* 1962. Donald G. Lux, ed.
*12. *Action and Thought in Industrial Arts Education,* 1963. E. A. T. Svendsen, ed.
*13. *Classroom Research in Industrial Arts,* 1964. Charles B. Porter, ed.
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*17. *A Historical Perspective of Industry,* 1968. Joseph F. Luetkemeyer Jr., ed.
*18. *Industrial Technology Education,* 1969. C. Thomas Dean and N. A. Hauer, eds.; *Who's Who in Industrial Arts Teacher Education,* 1969. John M. Pollock and Charles A. Bunten, eds.
*19. *Industrial Arts for Disadvantaged Youth,* 1970. Ralph O. Gallington, ed.
*20. *Components of Teacher Education,* 1971. W. E. Ray and J. Streichler, eds.
*21. *Industrial Arts for the Early Adolescent,* 1972. Daniel J. Householder, ed.
*22. *Industrial Arts in Senior High Schools,* 1973. Rutherford E. Lockette, ed.
*23. *Industrial Arts for the Elementary School,* 1974. Robert G. Thrower and Robert D. Weber, eds.
*24. *A Guide to the Planning of Industrial Arts Facilities,* 1975. D. E. Moon, ed.
*25. *Future Alternatives for Industrial Arts,* 1976. Lee H. Smalley, ed.
*26. *Competency-Based Industrial Arts Teacher Education,* 1977. Jack C. Brueckman and Stanley E. Brooks, eds.
*27. *Industrial Arts in the Open Access Curriculum,* 1978. L. D. Anderson, ed.
*28. *Industrial Arts Education: Retrospect, Prospect,* 1979. G. Eugene Martin, ed.
*29. *Technology and Society: Interfaces with Industrial Arts,* 1980. Herbert A. Anderson and M. James Benson, eds.
*30. *An Interpretive History of Industrial Arts,* 1981. Richard Barella and Thomas Wright, eds.

***31.** *The Contributions of Industrial Arts to Selected Areas of Education,* 1982. Donald Maley and Kendall N. Starkweather, eds.
***32.** *The Dynamics of Creative Leadership for Industrial Arts Education,* 1983. Robert E. Wenig and John I. Mathews, eds.
***33.** *Affective Learning in Industrial Arts,* 1984. Gerald L. Jennings, ed.
***34.** *Perceptual and Psychomotor Learning in Industrial Arts Education,* 1985. John M. Shemick, ed.
***35.** *Implementing Technology Education,* 1986. Ronald E. Jones and John R. Wright, eds.
36. *Conducting Technical Research,* 1987. Everett N. Israel and R. Thomas Wright, eds.
***37.** *Instructional Strategies for Technology Education,* 1988. William H. Kemp and Anthony E. Schwaller, eds.
***38.** *Technology Student Organizations,* 1989. M. Roger Betts and Arvid W. Van Dyke, eds.
***39.** *Communication in Technology Education,* 1990. Jane A. Liedtke, ed.
***40.** *Technological Literacy,* 1991. Michael J. Dyrenfurth and Michael R. Kozak, eds.
41. *Transportation in Technology Education,* 1992. John R. Wright and Stanley Komacek, eds.
42. *Manufacturing in Technology Education,* 1993. Richard D. Seymour and Ray L. Shackelford, eds.
***43.** *Construction in Technology Education,* 1994. Jack W. Wescott and Richard M. Henak, eds.
44. *Foundations of Technology Education,* 1995. G. Eugene Martin, ed.
45. *Technology and the Quality of Life,* 1996. Rodney L. Custer and A. Emerson Wiens, eds.
46. *Elementary School Technology Education,* 1997. James J. Kirkwood and Patrick N. Foster, eds.
47. *Diversity in Technology Education,* 1998. Betty L. Rider, ed.
48. *Advancing Professionalism in Technology Education,* 1999. Anthony F. Gilberti and David L. Rouch, eds.
49. *Technology Education for the 21st Century: A Collection of Essays,* 2000. G. Eugene Martin, ed.
50. *Appropriate Technology for Sustainable Living,* 2001. Robert C. Wicklein, ed.
51. *Standards for Technological Literacy: The Role of Teacher Education,* 2002. John M. Ritz, William E. Dugger, and Everett N. Israel, eds.

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

PREFACE

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

The yearbook is divided into three sections. The first section has been written to give the reader a broad overview of the yearbook as well as emphasis on such topics as how students learn, student diversity, current brain research, and how one's philosophical position comes into play when selecting different instructional strategies in the technology classroom.

The second section, entitled "Instructional Strategies for Technology Education," introduces a variety of new and updated instructional strategies that are suggested for use in the technology education classroom. Topics covered in this section include how students learn concepts and their importance, how to teach technology from an interdisciplinary approach, the importance and use of teaching social and cultural impacts of technology, design and problem solving, inquiry as a teaching method, cooperative learning, Web-based instruction, using modular technology environments, use of student competitions, and how to bring in community experiences in technology education.

The third section, entitled "Assessment and Summary," introduces the need for assessment of instructional strategies, how to assess if they have been successful and many suggestions of acceptable ways to assess one's own instruction. This section also summarizes the yearbook and reflects on the importance and need for continued improvement of instructional strategies in technology education.

52nd Yearbook Editors
Kurt R. Helgeson
Anthony E. Schwaller

ACKNOWLEDGEMENTS

The editors and authors would like to acknowledge Glencoe/McGraw-Hill for its continued support of the Council's Yearbook Series. This yearbook, *Selecting Instructional Strategies for Technology Education,* is the Council's 52nd Yearbook Edition. Without the support of Glencoe/McGraw-Hill and the efforts of Wes Coulter, Trudy Muller, and Jean Leslie, the profession would lose one of the most valuable annual contributions to the profession. It provides the profession and other disciplines with current issues brought forward by a variety of authors.

The editors acknowledge the dedication to the profession exhibited by the authors. Without their expertise and willingness to dedicate their time, this yearbook would not be possible. A final acknowledgement goes to Kathy Steffen of Ridgewater College and Marlene Stangl of St. Cloud State University for the review and editing of our manuscripts.

52nd Yearbook Editors
Kurt R. Helgeson
Anthony E. Schwaller

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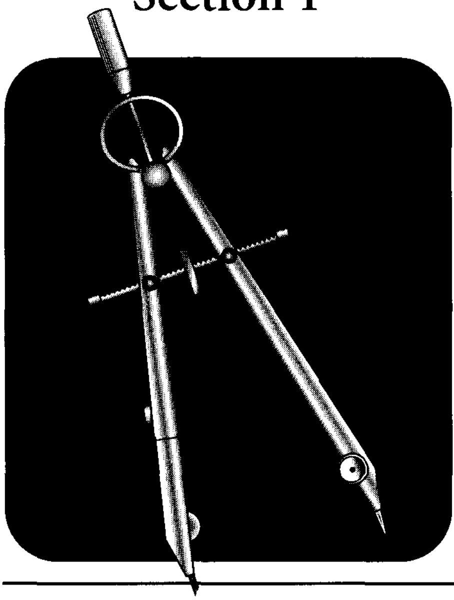

INTRODUCTION TO INSTRUCTIONAL STRATEGIES

Section I is designed to provide an introduction and overview of this yearbook. Chapter One, Introduction to Instructional Strategies, helps the reader understand the broad concepts of instructional strategies and the ways different instructional strategies fit with the continued improvement and development of technology education. Specific terms that are used in the remaining parts of the yearbook are defined and an overall model of the yearbook is presented. Chapter Two, Student Characteristics and Learning Theory, introduces the latest research on brain research and ways learning theory relates to diverse student needs and learning styles. Chapter Three, Individual Philosophy and Instructional Strategies, introduces the relationship between a sound technology education philosophy and ways this philosophy helps in selecting different instructional strategies. These chapters are introduced at this point so that the reader is better able to understand the remaining chapters in this yearbook.

Introduction to Instructional Strategies

Chapter 1

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INTRODUCTION

Technology education continues to struggle with the issue of being perceived as a project-based type of program of years ago. This perception is difficult to change. If we look at those programs that have changed this perception, they have several characteristics in common. These include such things as teaching to the *Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association [ITEA], 2000), (also called the *Standards* in this yearbook), being active in the curriculum process of the school system, and using a variety of instructional strategies to teach technology education. This yearbook is designed to provide information to the technology education profession on instructional strategies and the effectiveness of their use. The focus of this yearbook is to provide an understanding of the different instructional strategies for varying educational settings within a technology education program. It is important to understand that technology education can be taught in many instructional settings and with a variety of instructional strategies. Indeed, not all instructional strategies will work for the different instruction settings. This yearbook will assist with the selection of different instructional strategies based on student needs and the teachers' philosophies, develop an understanding of the advantages and limitations of the different strategies, discuss how to use various strategies to teach the *Standards,* and finally, identify assessment techniques to determine whether the instructional strategies are working as designed.

PURPOSE OF YEARBOOK

The primary goal of this yearbook is to advance the technology education profession. To that end, the discussion will be framed around the three primary ways in which this yearbook will advance the profession.

First, this yearbook will assist technology education teachers to understand and apply a variety of instructional strategies in their classrooms. This focus will help those who have continued to use more traditional instructional strategies to have a better understanding and increased awareness of contemporary instructional strategies.

Second, for those teachers who have begun the process of moving to a technology education-based program, this yearbook will provide excellent information to help design their instructional format. As teachers move to a technology education-based program, it is critical that their instructional strategies change as well.

Finally, this yearbook will assist technology education teachers with information and examples of contemporary instructional strategies aligned to the teaching of the S*tandards.* To help with this effort, each individual instructional strategies chapter will include content and examples of how the strategy relates to the *Standards.*

DESCRIPTION OF SECTIONS

Three sections comprise this yearbook. Each section will help with the understanding of instructional strategies and ways this understanding can be applied to the classroom and include:

- Section # 1: Introduction to Instructional Strategies
- Section # 2: Instructional Strategies for Technological Education
- Section # 3: Assessment and Summary

Section #1

This section (Chapters 2 and 3) is designed to provide information that will help readers understand the context of the yearbook, specifically, how the different potential audiences may use this yearbook. This section also gives some background information about how different philosophies, theories on learning, and the diversity of students in classrooms will affect ways in which the different instructional strategies should be selected and used in different instructional settings.

Section #2

This section is the heart of the yearbook. This section (Chapters 4–13) provides information about the different instructional strategies that can be effective when teaching technology education. Each chapter is dedicated to a different instructional strategy. Within each of the chapters, the format is similar. Each strategy is defined, its components discussed, and the appropriate use of the strategy is explained, particularly in relationship to the *Standards.* Finally and most importantly, each chapter contains information that shows how to use each instructional strategy in the classroom. Each chapter also contains several important discussion questions that can be used as a springboard for discussion in the technology education classrooms.

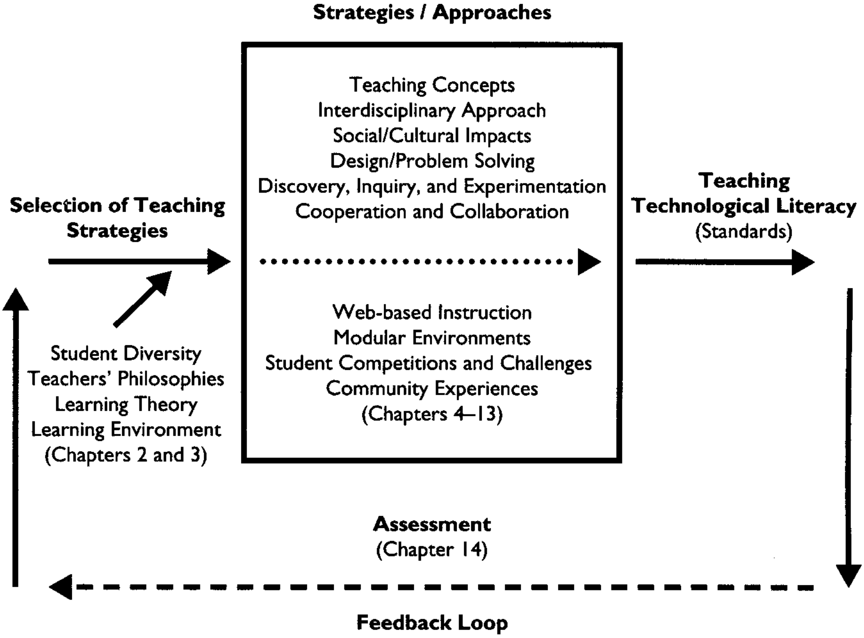
Section #3

This section (Chapter 14) provides a discussion about the assessment of instructional strategies. This section is designed to give teachers the tools needed to assess and evaluate whether they have selected the appropriate instructional strategies for their particular instructional setting. Because teachers can choose many ways to teach technology education and because what works for some teachers will not work the same for others, it is critical to understand some basic tools and possess information about how to assess the implementation of instructional strategies. This section also provides closure to the yearbook by the editors (Chapter 15) as a summary and reflection of the entire yearbook.

DISCUSSION OF MODEL

Many factors determine how a technology teacher will deliver material to a class. The selection of the various instructional strategies will be determined by many of the items shown in **Figure 1-1. Systems Model Applied to Teaching Technology Education,** the model used as the basis for this yearbook. While these factors are important to determine which strategy is selected, there is not room in this yearbook to discuss all of these factors. An overview of some of these inputs is discussed in Chapter 2, "Student Characteristics and Learning Theory," and Chapter 3, "Individual Philosophy and Instructional Strategies." This yearbook focuses on how to select the instructional strategies for the various educational settings based on the needs of the students, the curriculum, the teacher's philosophy and other factors that may impact the effectiveness of various instructional strategies. Finally, it is necessary to determine whether the strategies selected are, in fact, effective. This is the feedback or assessment component, which is a critical part of the selection of instructional strategies and the part of the basis for this yearbook model. This feedback or assessment is further discussed throughout the yearbook, in particular, in Chapter 14, "Assessment of Instructional Strategies."

Figure 1-1. Systems Model Applied to Teaching Technology Education.



INSTRUCTIONAL STRATEGIES

This yearbook is designed to be an extension of the yearbook published in 1988. At that time, Kemp & Schwaller (1988) stated:

> The course content for contemporary technology education programs may be accurately identified, selected and developed; however, it will not be effectively transmitted unless the instructor provides the right environment and opportunities for the students to learn the content.... Teachers simply cannot develop and/or transmit contemporary knowledge, skill and attitudes needed by students in the latter part of the twentieth century and beyond, using outmoded methods of teaching. Instructional strategies must keep pace with and match the technology content that is to be taught to the technology education student. (p. 18)

It is important to understand the definition of *instructional strategies* as teachers of technology apply the information in this yearbook to their individual classrooms. According to Kemp & Schwaller (1988) "[Instructional strategies include] all of the elements necessary in the teaching/learning process" (p. 17).

Although the need for changing the instructional strategies and content of teaching was important in 1988, it is critical today that changes and updates in instructional strategies continue to occur. The advantage technology education teachers have in the 21st century is the development and publication of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). These standards provide the content areas that need to be taught as part of a contemporary technology education program. It is now up to the technology teachers, departments, schools, and colleges to teach this content with the most appropriate, effective methods and instructional strategies possible based on the local learning environments.

One instructional strategy receiving considerable attention is using the Internet for delivery of instructional materials. As Moorhouse (2001) notes, "Changes in how education is delivered to students, in particular, the current and emerging array of distance education modalities, have compounded the questions pertaining to instructional effectiveness" (p. 8). Of concern are not only the resources necessary for the delivery of instruction through distance education, but also the outcomes of student learning (discussed in greater detail in Chapter 10).

Using a variety of instructional strategies has many benefits. Harris (2001) notes that pedagogical changes not only improve student learning, but also teach students strategies for independent learning. Fortunately, utilizing a variety of instructional strategies does not mean faculty must make drastic changes in their courses. Indeed, incremental adaptation will allow the teacher to use new strategies and become familiar with the new instructional strategies while managing the time required for change.

The selection of instructional strategies needs to take place in the larger context of the learning environment and the school curriculum. According to Thomas (1998):

> Theories of curriculum design and instruction are proposals about how best to organize and purvey educational content. Curriculum designs typically include consideration for the learning objectives to be achieved, the subject-matter content to be used in pursuing the objectives, suitable learning materials, effective instructional methods, and ways of evaluating the learners' progress. (p. 48)

Throughout recent decades, researchers have increased their attention to the way that a learning environment affects individuals' behavior. This attention reflects viewpoints about how environmental conditions influence learning that takes place under particular environmental conditions (Thomas, 1998).

While the focus of this yearbook will be on instructional strategies, other issues such as learning theory, individual philosophy, and assessment will also be addressed. Particular focus will be on the subject matter content that must be guided by the *Standards for Technological Literacy.*

DEFINITIONS

To help technology education teachers better understand this yearbook, several terms need to be defined. These terms will be used throughout the yearbook by the various authors.

Delivery Method. The system by which instruction takes place, which may include face-to-face, in-classroom instruction, or electronically mediated instruction (Moorhouse, 2001).

Instructional Strategies. All of the elements necessary in the teaching/learning process. This includes curriculum development, laboratory planning, and evaluation, in addition to the delivery system to be used in the teaching process (Kemp & Schwaller, 1988).

Assessment of Instructional Strategies. The process of evaluating the effectiveness of the delivery of the content. This differs from evaluation of student learning, which will be a factor in the assessment of the instructional strategies, but is only a part of the assessment.

Learning Environments. The physical education setting. This includes the building, equipment, and resources available for teachers to use to deliver the content. This environment and the status of the environment will impact the selection of the instructional strategies and the effectiveness of the teaching.

Delivery Systems. The actual methods which the technology education teacher uses to present the content. A delivery system is the method or way in which technology education content is conveyed to the students (Kemp & Schwaller, 1988).

Approaches. Broad styles of teaching that relate directly to the goals of technology education. These approaches help to identify a broad plan of action to help accomplish the teaching of technology education (Kemp & Schwaller, 1988).

SUMMARY

By reading and understanding content about various instructional strategies discussed in this yearbook, the technology teacher will have access to many updated contemporary instructional strategies to incorporate into the classroom. These contemporary instructional strategies can then be used to deliver the content of technology education in relationship to the *Standards.* In addition, the technology teacher will have a better understanding of how to assess these strategies to determine whether they are appropriate and effective in the classroom. Not all of the instructional strategies in this yearbook will work for every teacher in every learning environment. Consequently, this yearbook is designed to provide ideas. It will be the work of teachers throughout the profession to read, understand, and test the various instructional strategies in their classroom that will determine which will work for them. This yearbook is designed as an aid and not a prescription for teaching more effectively to the *Standards* in the technology education classroom.

DISCUSSION QUESTIONS

1. How does your philosophy affect the selection of your instructional strategies?
2. How do you currently assess the instructional strategies that you select?
3. How do instructional strategies relate to the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000)?

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Student Characteristics and Learning Theory

Chapter 2

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INTRODUCTION

It is impossible to keep students from learning. In fact, it is impossible to keep anyone, no matter what age, from learning. Interestingly, much of what has been found in recent studies on the brain and on learning applies to adult audiences as well. As people age, our brains continue to have the same needs and unique qualities.

The challenge in our school systems has been to focus the learning and to organize the environment so that all learners have the opportunity to be successful. During the last couple of decades, a wealth of information has become available to assist in this challenge. Neuroscientists have added to our knowledge of how people learn. In some cases the research has reinforced the information that was gathered on learning from the observations done for hundreds of years, but in other cases, new concepts have been introduced, which has changed the way people look at learning.

Technological advances have made it possible to really see how the brain functions. Up until this time, we have been able to look at only dead or diseased brains. With the advent of PET[1] scans and MRIs[2] and their use on the brain, we are now able to look at healthy brains and how they operate. The application of technology in neuroscience has led to an explosion of knowledge and new information is available to teachers daily concerning learning theory. Because of how quickly findings are being added to our storehouse of information, we must become discriminating users. It seems ironic that the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) have identified Medical Technologies as a focus of study, when in fact it is the Medical Technology area that now provides us with information about how to better teach in technology education.

[1]Positron Emission Tomography Scanner (PET Scan) gives a detailed view of an organ's activity. It shows the flow of blood and the use of energy. This shows which parts of the brain are being used during thinking, speaking, or moving.
[2]Magnetic Resonance Imaging (MRI) reflects the structure of an organ.

PURPOSE

The students coming to schools today are different from their grandparents and even their parents. Their brains function differently and are structurally different. By understanding how these learners function, we will enable them to become decision-makers, problem solvers, logical thinkers, and effective consumers and users of technology within our society.

Research on learning must be used in today's technology education classrooms to help teachers improve the art of teaching because "[t]eaching is the one process in the educational system that is designed specifically to facilitate students' learning" (Stigler & Hiebert, 1999, p. 3). The professional teacher in the classroom makes hundreds of decisions during any technology education lesson. The following is a summary of the theories that will give the professional educator more information on which to base those decisions.

PRINCIPLES OF LEARNING

Current Brain Research: A New Model of Understanding

Advances in communication technologies provide educators access to information at a level never before seen, a level that will only increase. Thus, the brain's challenge today is how to store information and access it when necessary, a process that requires all sections of the brain to work in conjunction with each other. The three major sections of our brains each have a specific job to do. The following is a summary of the brain sections and their major functions (Jensen, 2000).

Brain Stem. This section of the brain rises from the spinal cord and handles the functions of automatic behaviors of the brain like breathing, heart beating, etc. It also includes the cerebellum which is mainly dedicated to muscular coordination. Activities in this section are unconscious.

Mid-brain. This section of the brain is made up of structures that are situated more or less below the cerebrum. This section stores our emotions and their responses. Activities in this section are also unconscious. Emotions cannot be *thought;* they can only be felt. Thus, by thinking of an emotional situation, even if it is all imagination, the emotion will be felt by the brain.

Cerebral Cortex. This section of the brain is made up of four lobes that are involved with planning, problem-solving, processing higher sensory and language functions, hearing, memory, and meaning. Activities in this section are conscious.

The brain has two major tasks: to survive and to identify patterns. Because the survival instinct is based in the brain stem and mid-brain, actions taken are often unconscious. When under threat, the brain will downshift. This means that the brain stem and mid-brain take over when the concern is survival. If the learner is in the downshifted mode, then no learning is taking place because the cerebral cortex is not engaged. This may often be the case when students first experience the use of a power tool or other intimidating form of technology. While it may appear that students are learning about the use of this technology, fear, anxiety, or apprehension concerning the use of tools or other technology may in fact interfere with retention of critical detail for future safe operation.

Pattern seeking and making is also a part of learning, a very complex and necessary skill. All stimuli enter through the senses in a very chaotic manner, but the brain works naturally with complexity and multi-path learning. It looks for stimuli and information that will fit with what is already stored and files it. If the brain cannot find a place to connect the information, it will discard it or force it to fit. Technology educators need to be aware of this activity so that assistance with correct connections of information can be given to learners. Thus, the connections should be made obvious to students and rechecked. Technology educators can assist students' brains in making connections to previous learning by comparing or contrasting the current learning to previous experiences. In the case of electricity, for example, teachers will often use a water analogy (water pressure, flow, control valves) to enable the brain to connect new information with something it already recognizes.

Although we are born with all the neurons we will need, our brain cells continue to expand with the growth of dendrites that connect the neurons. Dendrites are extensions from cell bodies that receive information from other neurons. The brain begins at birth to make random connections that are stabilized through experiences. Many of these connections are made before the age of 10. Any neurons that are not needed are pruned. While most of the pruning takes place between ages 10 and 16, a slowdown in the acquiring of new skills may be observed, but cognitive development based on additional spurts of dendritic (branching) growth still occurs. This dendritic growth continues all through adolescence and adulthood based on experiences and learning (Diamond & Hopson, 1998).

Although the brain continues to change with age and activity, critical periods exist for brain development. Research shows that by continuing to learn new things, our brains stay stronger and healthier. Ultimately, the onset of mental atrophy is delayed. Furthermore, because each brain develops on its own cycle and is unique, the age at which we begin to walk and talk is not an indicator of how well we will perform later. We need to respect that when a new skill is learned is not an indication of innate ability or talent. Eric Lennenberg (1967) has identified three spurts of brain growth: one is around age two for walking and talking; the second around age six when we start to read, do math, and write; and again around the age of 12 when we begin to think abstractly. Although learning continues after this point, it is more difficult; consequently, the more experiences students have before puberty the more resources they have to build on as adults. This fact adds credence to the ITEA effort to move technology education into the elementary level. Experiences at that age will "pre-wire" the brain to better deal with technologies in later life.

To learn something, the brain must store information in long-term memory. To be stored in long-term memory, the brain must have a use for the information. It must have an emotion attached, and it must be contextual: "We remember what we understand; we understand only what we pay attention to; we pay attention to what we want" (Bolles, 1988, p. 23). The brain's short-term memory stores information in a finite number of memory spaces, an abstract concept to help in the understanding of how much information the brain can use and handle within a period of time. These spaces, which can increase up to approximately seven spaces, are used for storing the information that is coming in and that the brain is focusing on. To allow the memory to handle more information, it must be "chunked." Instead of remembering each small piece, pieces of information must be joined into larger chunks. Dr. Benjamin Bloom (1964) found that people considered experts in their fields were able to chunk large quantities of information, which allowed them to work with more information at one time. With the chunking of information, the learner begins to look at the experience in more complex ways, which is why an "expert" in something can see connections that a "novice" would be unable to see. If the brain is unable to chunk information, it will continue to function on a novice level, as well as at the speed of a novice. Technology educators can assist students in chunking information by presenting new information in a way that represents the relationship among the information. They can also use graphic organizers and "thinking aloud" to model how the educator (expert) is chunking the information.

<u>*A Brain-Compatible Learning Environment*</u>

A continual argument has yet to be resolved by recent research on the balance of nurture and nature. Although both genetics and environment affect learning, the balance in the equation for each learner is unique. Everyone's brain is different and different factors play a role in varying degrees. Many things affect learning. Some of the factors are life experiences, health, nutrition, genes, temperament, prior learning, and safety of environment (emotional and physical). Since we know that the brain's structure actually changes with every experience, we can use the environmental factors to enhance or lessen the genetic factors. The following terms will help to understand these environmental factors.

Safe Environment. Any feeling of threat allows the brain to downshift. When the brain is in this mode, learning does not take place. The feelings of threat can be different for each learner in the classroom. The threat can be an academic one: "I don't know how to do this! I must be dumb!" Or it can be emotional: "No one cares about me at all!" Or it can be a social one: "I never know the right thing to say!" Helping students know that these are feelings to be dealt with can in many ways relieve the threatening atmosphere. Furthermore, care must be taken to identify the difference between threat and stress. A degree of stress is beneficial for learning. Effectively learning how to safely use a piece of equipment is again an example of the balance needed here. Students must have enough "stress" to pay attention and engage in the learning but not so much fear to force the brain to downshift. Instructors need to monitor student responses and adjust the approach to obtain the most beneficial level of stress.

Enriched Environment. The rat studies done by Marion Diamond, Ph.D., and others prove that rats living in an enriched environment have larger brains. It was found that the impact of the environment was widespread through all parts of the brain involved with learning and memory. The factors that made for the enriched environment were other rats, toys to use, and the changing of these toys on a frequent basis (Diamond & Hopson, 1998). This phenomenon may account for the success of modular labs in technology. Students are paired together, work with actual technological apparatus, and rotate to new modules every 7–14 days (Modular Technology will be discussed in Chapter 11).

Emotion. Damasio (1994) has researched the effect of emotions on learning. By studying people with brain damage whose frontal lobes (for thinking) were separated from their mid-brain (for emotion), he found that these patients performed normally on traditional intelligence tests but were unable to plan and make rational decisions. He found that for learners to do rational decision-making and planning, they must have access to the emotions. Experiences presented to students with no emotional impact will not be connected in long-term memory. Information not remembered or retrievable means the information is not learned. Instructors can "build emotions in" to lessons by developing activities that are directly related to the things that interest students.

Activities. Learning experiences need to be presented in as many modalities as possible. This allows students to access the information in the mode that is the most powerful for them. It also allows them to use their secondary modes to enrich and elaborate on the information incorporated. The use of music, physical activity, and mind mapping (Buzan, 1996) in classrooms has allowed more students the opportunity to be successful, especially those whose strength is not the traditional modality used in most school settings (auditory). Once again, the environment and instructional approach of a typical technology laboratory is very brain compatible: students physically engage with tools, materials, modular equipment, computer technology, etc., and often are given some latitude in approaching problems and developing solutions. However, it is all too easy for instructors to promote one approach as being best when in reality each student's unique brain structure may require a unique approach to be most successful.

Gender Studies. Research has also shown that gender plays a role in the structure of the brain. While more studies need to be done to identify how much effect gender has on learning, it appears that each gender has skills and abilities that are learned early. Males seem to develop language skills later while females develop spatial and physical skills later. This uniqueness is not representative of abilities but rather stages of development (Moir & Jessel, 1991). During adolescence the hormonal changes in the body do affect how the brain is functioning, but many of these effects are in the brain stem and mid-brain, which means they are at the unconscious level.

Procedures. The brain is designed to focus on what is new. Consequently, what we want the learner to pay attention to and learn must be presented in novel ways. We do not want the procedures in the classroom to be the novelty; we want them to be routine. The learners should not be using any of their memory spaces on learning and relearning classroom procedures. These procedures should be taught and practiced to a level that they become routine, helping the learners feel safe from procedural mistakes and helping them create memory space for the "real" learning. Once again, we must not lose the traditional strength of technology education—the hands-on minds-on laboratory.

Reality. Because the brain looks for contextual meaning, the closer the learning can be to the real world the better it fits with other experiences. Susan Kovalik's ITI Model has expressed the typical input in a classroom as second-hand and symbolic while the input needed to be brain compatible is presence and immersion. The challenge is to find a way to engage the learner with simulations and building scenarios to replicate the real world (Kovalik & Olsen, 1998).

Physical Needs. Certain physical needs, such as sleep, nutrition, and hydration, must be met for the learners to function at their optimum. Research has shown that the sleep patterns of the adolescent are quite different from those of adults or even younger children. Because of changes in the brain brought on by hormones, adolescents fall to sleep later and awaken later in the morning. The schedules of most educational systems do not reflect this need. Consequently, many adolescents have trouble focusing in the morning and can suffer from sleep deprivation (Wolfson & Carskadon, 1996). What a learner eats is also critical to learning. The need for protein and complex carbohydrates on a scheduled basis continues to be proven in many studies. One of the major findings discussed by Eric Jensen (2000) and reinforced by recent studies is the amount of water needed to learn. Water is the vehicle used by the body to transport the energy (glucose) needed by the brain to operate. It is absolutely necessary that people drink enough water to be hydrated at all times. This means that a student should be drinking a glass of water about every hour throughout the day.

Social Needs. As in the rat studies, humans need to be with others. The unconscious parts of the brain, especially in the limbic system, look for the emotional connections that are found with working and playing together. Group work is a classroom technique that has been shown to be very brain compatible, especially from the age of 11 on. The procedures for group work need to be established so that they become routine and the learner does not feel any social threat. The novelty should be the work done by the group, not the group working together (unless learning to work as a group is the intended learning). Thus, the technology education classroom should establish set groups for group projects, define roles within groups, and sustain those groups and role for the duration of the course or project.

LEARNING THEORY MODELS

Social scientists have always been interested in *how* students learn. Research about learning today emphasizes the understanding and demonstration of knowledge. Just *knowing* something is not adequate, but using what you know is the critical factor. Because of the diversity of students that are in our educational system, studies have focused on varied populations of learners. Much of what has been learned about special populations appears to be transferable to other groups. There seems to be some common factors we can keep in mind when working with each and every student in the classroom. The following are summaries of some of the theories and models for learning that are compatible with the most recent research on how the brain operates and possible connections to the technology education laboratory.

Constructivist Theory

It is felt that students make sense or construct their new learning based on what they already know and believe. For the purist, that would mean that you never tell learners anything: you just let them experience it. Others believe that building on pre-existing knowledge is important but that *teaching by telling* also has its place in the constructivist model (National Research Council, 1999). It is important to know their pre-existing knowledge when helping students make the correct connections in their long-term memory. The brain is always trying to make sense of the stimuli it is receiving. It will "fill in" what is needed to connect with an existing schema. Once information has been stored and practiced, it is more difficult to change because the brain is comfortable with what it has done with the information and is resistant to change. Since the brain needs to work quickly as a result of all the stimuli it receives, it is more efficient in a classroom to identify pre-existing knowledge before beginning new learning. In whole classrooms, this can be accomplished with pre-tests, group questioning techniques, and articulated scope and sequences of curriculum so that sequential classes build upon previous curricular experiences. In the case of individual students, teachers can determine pre-existing knowledge through informal interviews and observations.

Multiple Intelligences Theory: Multiple Instructional Approaches

To understand Gardner's Multiple Intelligences Theory, it is best to pair it with Sternberg's model of mental processes. Gardner (1983) delineates intelligence into eight different domains.[3] Sternberg (1997a) discusses the three processes used for mental self-management.[4] Sternberg's processes are used with all eight of Gardner's domains. People have strengths in each of the intelligence domains. By identifying a student's strengths, a teacher or parent can enhance them and use them when introducing new concepts. This does not mean that the other intelligences should be ignored. New learning presented for the first time in a student's strength area has a better chance of being correctly stored by the brain in long-term memory. If Sternberg's processes are learned and used in a variety of contents, they will become compatible with how a student's brain is functioning. Technology educators basically have two options in addressing this issue: use an assessment instrument to determine the strengths of students in class or simply assume that most (if not all) of the domains will be represented in the student population and vary the instructional so that all domains are addressed. It is much too easy for teachers to get locked into a presentation mode that they like or simply assume that "what worked for me is going to be good for all students."

Learning Style Theory: Big 5

An efficient and effective brain must be able to retrieve information once stored. Richard Bandler (1982) stated that three criteria must be in place for the brain to decide it really does know something. It must be reinforced in the learner's learning style, it must be repeated, and it must be validated for a length of time. Knowing that the learner's style is important has been accepted in educational circles for some time. How to identify and talk about that style has been more difficult. The concept of styles has been developed in many areas: learning styles, personality styles, thinking styles, management styles, problem-solving styles, etc. What most of these models have in common is what has been termed the "Big 5." These aspects have been observed in newborns (Halverson, Kohnstamm, & Martin, 1994), as

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[3]Linguistic, Musical, Logical-mathematical, Spatial, Bodily-kinesthetic, Intrapersonal, Interpersonal, and Naturalist.

[4]Componential (or academic), experiential (or creative), and contextual (or "street-smart").

well as in adults. All the models delineate these areas in some fashion: 1) Negative Emotionality—one's capacity for dealing with stress; 2) Extraversion—one's capacity for sensory stimulation; 3) Openness—one's breadth of interests; 4) Agreeableness—one's tendency to submit to or defy others; and 5) Conscientiousness—the degree to which one is self-disciplined and focused on goals (Costa & McCrae, 1992).

Although these traits seem to be genetic, they should not be confused with learnable skills. The traits are usually placed on a continuum with no person having a pure trait because people are complex and consist of a unique mixture of degrees of each trait. These traits appear to be very difficult to change but can be used to facilitate learning. Knowing what strengths a learner has allows the teacher to make better decisions that will enhance the learning. In identifying the style, most of the models are useable in that they give learners and teachers a common language to use.

Proster Theory

Leslie A. Hart (1998) developed the Proster Theory in the 1970s and has updated it to use the brain research available today. The Proster Theory means a program structure, which is a collection of programs all for the same general purpose. He defines a schema or program as a sequence used for attaining a pre-selected goal. Schemas are triggered when the learner recognizes a pattern. In the technology classroom, for example, a student may recognize that a system exists (the pattern of input, process, output, and feedback is recognized) and can then apply schemas to deal with that system (methods of central systems, interrelationships of components, etc.).

Learning in its simplest form is the forming of new schemas/programs or accommodating new experiences to old ones. Forming new schemas or programs occurs in this basic cycle:

- Evaluate the situation or need: The learners must be able to identify patterns or schemas/programs.
- Select the appropriate schemas/programs: The learners can select only from programs they already possess. The learners need to acquire the schema/program before it can be used. The learners must have an opportunity to select, not always be told, which schema/program to use.
- Implement the schema/program selected: The learners must be given a chance to try their program. It is important that students actively engage in what they have planned.

Hart's theory is brain compatible because it focuses the instruction on how to store programs with connections between bits of information rather than on how to store individual bits of information. It also focuses on students being the decision-makers concerning what to use and how to use it. This process is much more complex and interrelated, which is how the brain likes to work. Helping students adapt and change their schemas/programs would also be critical for learning. Technology literacy could be viewed as a brain structure that allows an individual to encounter, identify, and efficiently deal with technological information/situations. And a large structure requires a large foundation. Therefore, if students are to attain technological literacy to the degree necessary to effectively interface with an increasingly technological world, the learning experiences and schemas developed must begin at birth—or certainly no later than kindergarten in our school systems. The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) shift us from a secondary focus to a K–12 focus and begin to develop schemas for dealing with technology at age five (selection and application schemas, design schemas, and problem-solving schemas). These schemas will be reinforced and refined throughout an articulated K–12 technology education program.

STUDENT LEARNING

Since experience alters brain structures and specific experiences have a specific effect on the brain, the experiences in a learning setting are directly connected to the learning. The brain is not passive in learning. When new information is presented to the learner, the brain will look for patterns and a schema to which the new information can be connected. It will also add other pieces of information to these connections. Some of the connections may not be correct because the memory process has no way of knowing what is true and false. This has been demonstrated many times with discrepancies between the testimonies of eyewitnesses to the same event. Unless conflicting experiences are designed and presented, learners will continue to believe the "reality" they constructed with their first experiences.

We also know that some experiences have more power because they come during a particular development growth spurt. Care needs to be given so that critical experiences and learning are available for the learner and connections of that learning are checked. The matching of these factors allows students to make strides in their development and to create a positive self-image of themselves as learners. When the experiences and learning are presented at a less opportune time, the learning may not happen and students may begin to feel incapable.

Again, according to Csikszentmihalyi (1990), students need to encounter the appropriate level of stress to learn. They need to feel some stress and excitement from the novelty of learning new concepts. They also need to feel that with work on their part they can handle what is in front of them. However, the stress cannot be so high that it begins to be perceived as threatening. They also cannot feel that they are incapable of handling the concepts even with hard work. Finding this middle ground is one of the skills of teaching. Sequences of technology courses at the high school level, for example, need to be articulated so that students are not repeating information and experiences (no novelty) and yet each course needs to control the rate of new information and experiences so that students feel that requirements are attainable.

Furthermore, the brain is always looking for patterns, storing patterns, and testing patterns. To do this the brain needs to be in some control of its learning. Martin Seligman (1991) discusses the phenomena of learned helplessness. If humans feel they have no control over their environment or learning, they give up. Their focus goes to other things. Students need to be encouraged to feel in control and able to manipulate their environment to optimize their own learning. Seligman has found a way to teach through his ABCDE[5] model How to Be in Control of Personal Attitude.

Finally, as learners begin to experience and connect new learning, they need immediate, specific, and frequent feedback. Feedback allows them to change poor connections, incorporate new processes into their schemas/programs, and move ahead on more complex aspects of the learning. The feedback does not need to come from the teacher; it can also come from peers. To be the most effective, some learner choice should be involved. Teaching students to give feedback to others helps them with their own self-monitoring skills. A lecture-based technology classroom could never accomplish this. Students need to be arranged as pairs or small groups with both opportunities and expectations that provide feedback to each other, and frequently interact with the instructor so that misinformation

[5]Adversity, Beliefs, Consequences, Disputation, and Energization

and inefficient schemas are not reinforced. In modular technology labs, for example, students may need to be taught how to interact with their partner constructively; thus, the teacher needs to be constantly monitoring, moving throughout the lab, and intervening as necessary.

DIVERSE LEARNERS

Special Needs

We are ethically and legally required to set up a technology classroom environment in which every student has the opportunity to be successful. Indeed, all students have needs that must be met for learning to take place, though some students have more complex needs. By applying what we have learned about how the brain functions, we can be playing to student strengths rather than just identifying their weaknesses.

Adapting the learning environment and modifying instruction is something that must be done for all students. It is only the degree of modification that is different. Students that have been identified with a disability are the ones we think of first, but the teacher in the classroom is consistently accommodating and modifying as appropriate for optimal learning to take place for every student. Many of the accommodations that have been developed for different levels of learners may work for all levels. For example, we begin with the "big picture" with our more capable learners but start with the subtasks for less capable learners. Starting with the "big picture" for all levels aids in students' understanding of where they are going and how what they are doing fits with that "big picture." Because the brain likes to see the whole and works better with realistic context, providing these contexts to all levels of learners increases their chances of learning more. Just as knowing the "big picture" is important for all levels, practicing the subtasks is also important for all levels. With the brain's capability for "filling in" missing pieces, the brain may make incorrect connections when the subtasks are not openly checked or taught.

As classrooms become more brain compatible, they also tend to present concepts in a more concrete format. This works well for students with disabilities and students with particular learning styles and has long been a strength of industrial and technology education courses. Ergonomic technologies have also developed tools to enable the physically handicapped student to function even more efficiently in technology learning settings.

Social Impact

Besides designing opportunities to increase the chances of success for all in the educational setting, we are obligated to strive for success for each student individually. Students should be considered individually; otherwise, we may ignore their unique developmental cycles. The age at which something is learned or the amount of time needed to learn does not indicate how well something is learned. Knowing that much of what happens in the brain stem and mid-brain is unconscious, we need to assist our future technology students in learning to look at their world with an understanding of the impact emotions have on learning and working. Teaching students about how their brain works gives them information that allows them to impact their own environments. Being able to look at behavior as a learning opportunity first rather than a disciplinary issue may change expectations in today's technological society.

We know that the brain uses the complex sensory data it receives to make decisions. When communicating with others, the brain depends on complex sensory data it receives such as body language, facial expression, physical proximity, and voice inflections. With the expansion of technology into the area of communication, it will become necessary to assist learners in collecting data without face-to-face interactions. By removing this set of stimuli, the brains of today will again need to adapt.

Economic Impact

Learning in the classroom and learning in a diverse workplace have much in common. The strategies that have proven to be more brain compatible in the technology classroom are the same strategies that the business world has found to be more efficient. Examples include working in groups, using problem-solving strategies, working in the 3-dimensional world, developing ownership of own learning, and knowing how to use the brain's ability to construct learning from patterns. Thus, the teaching and practicing of these procedures and processes are preparing our students to be successful in the workplace. Learning where and what they are doing fits into a real context and also encourages the transfer of skills.

Learning is a lifelong process. Consequently, by making the learning environment more brain compatible, we make learners feel successful about their learning capabilities throughout their life. The brain must continue to learn because learning new concepts keeps it healthy. In addition, the ability to learn cannot be consciously shut off. Ultimately, making learning a positive experience ensures that tomorrow's workers are open to learning new technologies.

By teaching our technology students about the functions and unique characteristics of their brain, they will be better able to develop life-long habits that foster learning. When new learning becomes necessary in their lives, they will be able to design the situation to assist them in understanding the concepts needed. Being in control of one's own learning becomes an intrinsic reward in itself.

SUMMARY

According to the theories and models reviewed here, a brain-compatible learning setting would include a teacher who presents in a variety of modalities, like active hands-on and "teaching by talking." A technology teacher is needed who interacts with students, individually and in groups, demonstrating an understanding of developmental cycles. Teachers need to design activities to enhance individual uniqueness, including special needs and learning styles. The information should also be presented from whole to part, while identifying pre-existing knowledge of students and planning learning experiences with that in mind.

We need students who work individually and in groups. In the ideal setting, they would construct their own meaning based on their pre-existing knowledge and be able to work in their learning style for at least part of the day; they would make decisions concerning their learning; and they would be able to demonstrate their learning in a variety of ways. In addition, the feedback would be immediate, relevant, and specific. Students would feel safe, physically and emotionally. They would also be hydrated, properly fed, and rested.

A brain-compatible classroom has a balance of novelty and routines and is designed to meet the physical needs of the learner. The setting is free of threats (physical, emotional, and social), yet has an appropriate level of stress for learning.

Our students must be as efficient and effective as possible because there is so much to learn and because it is unknown what will be needed in the future. Consequently, we need our learners to be quick processors with the many types of tools they are able to use in their thinking. Since we are beginning to understand more about how the brain functions and learns, this knowledge must be put to use to give our students their best chance for success.

By working toward understanding, not just memorizing of knowledge, we allow our technology students to make the decisions needed in problem-solving situations. They will have the cognitive tools to troubleshoot, research, develop, and innovate. Continuing to motivate our students to spend the time needed to learn, and setting up the learning environment so that every student has the opportunity to be successful, will be critical in the learning settings of today and tomorrow.

DISCUSSION QUESTIONS

1. What is the importance of having a safe environment when learning is taking place?
2. Why is it important to use a variety of instructional strategies in the technology education classroom?
3. What effect does age and gender have on learning in the technology education classroom?
4. Why is it important to set up differing instructional strategies for diverse learners?
5. What are some of the reasons why group interaction is important to the learning of future technology students?

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Individual Philosophy and Instructional Strategies

Chapter 3

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INTRODUCTION

Knowing, believing, and valuing—every teacher is guided by a personal philosophy of education. What we believe to be important in terms of imparting knowledge and values underlies the many decisions we make concerning curriculum, content, and instructional strategies. Understanding our own philosophy and how it permeates educational activity helps us understand *why* we select particular content and instructional approaches, *what* we value in our students, and *how* the study of technology, as it manifests itself in our classroom-laboratories, differs from other school subjects. This chapter will consider philosophical positions and ways to clarify personal philosophies about instructional strategies that are used to teach technology.

Philosophy literally means "love of wisdom" (Zais, 1976, p. 103). Philosophy involves our judgments of what we know and believe, how we come to know it, and what we value. Ironically, while philosophical studies can be confounding and seemingly far removed from what happens in the technology classroom-laboratory, our conception of the world influences what we decide to teach and how we teach it.

Philosophy has three important components: ontology, epistemology, and axiology. Ontology asks the questions: What is real? What does it mean to be? The theory of being is behind ontology. Ontology is the basis for fundamental philosophical positions: human-centered, earth-centered, and other-world centered. Epistemology deals with the questions: What is true? How do we know the truth? The theory of knowledge is explained by epistemology. Axiology deals with our response to the questions: What do we value? What is good? Our responses to questions concerning what is real, true, and good provide the ingredients for a personal philosophy for teaching and learning as well as instructional strategies in technology education.

PURPOSE

The purpose of this chapter is to discuss the role that an individual's philosophy has on the selection of instructional strategies. The selection process for instructional strategies, unlike content and facilities which are generally school driven, are at the discretion of the classroom teachers. Through an examination of philosophies and the basis for the different philosophies, one will develop a better understanding of the relationship to selecting and using the various instructional strategies.

PHILOSOPHICAL POSITIONS

A variety of philosophical positions deserve attention. When selecting instructional strategies, it is important to have an understanding of the various philosophical positions.

Other-World-Centered Philosophies

In other-world-centered philosophies, reality, knowledge of truth, and goodness are absolute. Reality exists in another world or in the cosmos. While knowledge is received or revealed, goodness is in the form of the ideal. Schools of thought for other-world-centered philosophies are represented by religions, idealism, and transcendentalism. Socrates (469–399 B.C.), renowned as a great teacher, embraced this school of thought. He turned away from the traditional study of the cosmos and focused on discourse about man. Socrates' arguments were based on objective definitions. The inner person was the source of truth, which was revealed by studying one's soul. The philosophy of Socrates is captured in his view that "the unexamined life [is] not worth living" (Palmer, 1994, p. 45).

Plato (427–347 B.C.), a student of Socrates, believed in the world of pure ideas. Plato held that the minds and souls of humans are filled with pure thought that is lost to consciousness and must be recalled. Learning takes place by stimulating the senses, by Socratic questioning, and by contemplation. His view was more metaphysical (a worldview), systematic, and other-worldly as compared to Socrates. One fundamental question guided Plato's philosophy: Is there a perfect world? In his view, there were two worlds—the world of things that are seen (imitations of what are real) and the world of perfect forms or models of everything on earth that are unseen (the ideals). It was this tension between imitations of reality in the form of everyday objects and ideals as the highest form of reality that was the basis for Plato's work. The founder of the first university, called "the Academy," Plato developed a philosophy that translated into a curriculum for the elite, in which the practical was avoided. Because education was intended for a select few who were intellectually endowed, classical studies were guided by other-worldly philosophies. Such philosophies have contributed to classical studies such as religion or the humanities. Studies associated with technology typically are not based on this philosophical position.

Earth-Centered Philosophies

In earth-centered philosophies, reality exists in this world. While the knowledge of truth is discovered by reason or using the senses, goodness, or what is valued, is defined by the laws of nature. Schools of thought for earth-centered philosophies include rational realism, empirical realism, positivism, naturalism, and materialism.

Aristotle, a student of Plato, believed the physical universe was made up of matter and form. In combination, matter and form produced the entities we encounter in our world, whose nature strives for its own perfection. Just as the search for knowledge is inductive, beginning with sensing and culminating in generalization, scientific inquiry leads to discovery of the truth. Productive activity, on the other hand, sapped energy away from thinking. When Aristotle dichotomized theory (for the thinking class) and practice (for the working class), Greek traditions became established out of this set of beliefs, which held that practical knowledge is not fit for schooling, workers will obtain it naturally, and schools are for an elite class. Math and the sciences are prominent in curriculum based on earth-centered philosophies.

Human-Centered Philosophies

In human-centered philosophies, knowledge of the good is constructed from experience. People develop such knowledge by putting ideas into action. Every person is her own authority who through experience has access to knowledge of the good. Pierce and James (Zais, 1976) believed that ideas are a plan for action. Thus, emphasis in human-centered philosophies is in a future rather than a past orientation. In this philosophy, the acquisition of knowledge is intended for the masses rather than an elite class. Zais (1976) sums up this school of thought in the following: "Reality is relative and a function of human experience, knowledge of truth is constructed, and goodness is the preferred consequence" (p. 123). Technology education has evolved essentially from human-centered philosophies.

PHILOSOPHICAL FOUNDATIONS FOR TECHNOLOGY EDUCATION

Charles Pierce (1839–1914) invented the term *pragmatism*, as a "method whose primary goal was the classification of thought" (Palmer, 1994, p. 276). Pierce held that beliefs produced habits, that beliefs were rules for action, and that habits established direct access to mental processes. He contended that a person's belief could be ascertained by observing the person's actions. Pragmatism then, as a human-centered philosophy, describes reality on the basis of human experience. The process by which a person comes to know reality is important. Pragmatism also recognizes that human experience involves actions and consequences. Knowledge is tentatively true, has a social reference, and is constructed from experience. Processes leading to knowing include reading, writing, speaking, problem-solving, and data gathering. This view translates into curricular emphases dealing with thinking processes or human activities, social studies, and social problems. Thus, curriculum guided by pragmatism is often learner-centered and process-oriented. Furthermore, technology education curriculum that is problem-solving-based is pragmatic in nature.

John Dewey (1859–1952) is perhaps the best known pragmatist. Dewey contextualized philosophy in terms of society, culture, and history. He suggested that the purpose of reflective thought is to turn obscurity to clarity; this is knowledge. Hence, knowledge is constructed by the inquiring mind which seeks to clarify what was formerly unclear. People learn routines that go beyond instinctual responses—as a way to solve problems. Knowledge "'marks a question answered, a difficulty disposed of, a confusion cleared up, an inconsistency reduced to coherence, a perplexity mastered.' Ideas are plans for action. . . . Thinking is simply 'deferred action'" (Palmer, 1994, p. 285). Dewey made no distinction between scientific facts and values because he believed scientific techniques should be applied to the development of values and social reform (Palmer, 1994). For Dewey, education was a socializing agent, an agent that shaped society. Everyone has something to contribute to the construction of social institutions, according to Dewey. Democracy and education have the same goal: the full development of individuals as human beings. In *Psychology of Occupations*, Dewey offers a view of school as a "miniature society" (Dewey, 1900, pp. 82–84). Ideas were tools to solve problems in the environment: "Dewey saw the mind as a problem-solving tool that continually adapts to the environment in the same way that creatures evolve different characteristics" (Weate, 1998, p. 59). From this view, Dewey regarded curriculum as a construct based on people's fundamental needs. Further, children's interests and talents should be taken into account to capitalize on natural instincts: constructive, investigative, experimental, social, and expressive. Dewey advocated balanced integration of intellectual and sensory experiences in school curriculum, much like the most important lessons learned outside the classroom. Technology education, with increasing emphasis on constructivism, authentic learning, the development of multiple intelligences, and cooperative learning, is deeply rooted in Deweyan thought.

Philosophy in Curriculum and Instruction

Philosophy provides the knowledge from which we make curricular and instructional strategies decisions. It is, in effect, a master plan that drives our perceptions and our actions in the technology laboratory-classroom. Basic philosophical positions ultimately translate into curriculum theories that further focus our philosophical positions. Zuga (1993) states that curriculum theories "are the beliefs that guide practice through the selection of methods and content" (p. 9). Changing philosophical positions and fundamental beliefs influenced the evolution of technology education and major curriculum efforts.

Kliebard (1985) identified the following categories of curriculum theories: social efficiency, human development, and social emeliorism. For *social efficiency curriculum theory*, the goal is to prepare students to perform effectively in societal roles, encouraging a traditional approach to education. Thus, students' heads are regarded as empty vessels to be filled and as raw material to be molded. The focus is on goals, objectives, and outcomes: "Instruction is efficient to the extent that course objectives are mastered" (Herschbach, 1992, p. 18).

The work of Ralph Tyler (1949) dealing with the development and use of objectives for curriculum and instruction is aligned with this theory, which means what to teach is determined by great books, works of art, and scientific innovations. Social efficiency theory is based on the widespread belief that the purpose of schooling is to produce an efficient and productive workforce. The Industrial Arts Curriculum Project (IACP) of the 1960s reflects social efficiency theory. IACP was based on the premise that "[i]ndustrial arts, appropriately conceived and taught, can provide an understanding of how man manages industrial production, of the practices he employs to change resources into man-made goods, and of the knowledge of how to efficiently use and service these goods" (Towers, Lux, & Ray, 1966, p. 26). Current curricular focus on proficiencies and preparation for a technical workforce is aligned with the theory of social efficiency. Consider this classroom-laboratory vignette:

> The class bell rings. It's 8:15 A.M., Thursday, in Mr. Burns' eighth-grade technology class. The objective for the lesson is written on the whiteboard: *Students will use the problem-solving steps for technology class to solve a given problem.* Mr. Burns waits for his students to be seated in their assigned rows, then announces, "Open your notebooks. Today I am going to review what you learned about the problem-solving steps for technology class. Who remembers from yesterday the first step?" Sean responds, "Figuring out what needs to be solved." Mr. Burns corrects Sean with the textbook definition he wrote on the board the previous day. "Now, what are the other steps for problem-solving?" He asks several students before Maria responds with the correct answer. Next, he assigns his students to work on a specific problem: "This is the problem: The cafeteria has trouble collecting and storing the used foam trays during lunch. Create a stand that will allow the lunch trays to be stacked evenly and no higher than three feet." The students work individually on this problem and check off each problem-solving step with the teacher. Students are graded on their sketches, their procedural steps, their stand, and their daily log sheets.

This teacher-directed, traditional class was intended to achieve conformity, efficiency, and successful completion of the objectives for the unit. Implicit in this example is the underlying theory of social efficiency.

Human development theory says curriculum is created from ways children normally develop (Kliebard, 1985). Higher-order thinking, problem-solving, and personal needs are central. This curriculum theory is an outgrowth of the naturalism of Rousseau's and Dewey's ideas. Because children are inherently curious, instruction should capitalize on their curiosity. Students are active participants in schooling. As this theory suggests, problem-solving and investigation are keys to successful education, which means activities should structure the curriculum. Many theorists espoused "learning by doing" as an essential aspect of human development theory. Bacon (1561–1626) espoused that the upper class should study trades for knowledge; he talked about educational progress in terms of educating the masses. Comenius (1592–1670), the father of modern pedagogy, advocated the use of all the senses to acquire knowledge, learning through inductive thinking, and to teach objects before their characteristics (Martin & Leutkemeyer, 1979, p. 21). In addition, Comenius believed in a national system for education and in the formal training of teachers. Rousseau (1700s) advocated mental training to give meaning to academic learning. He felt instruction should be aligned with the natural developmental stages of individuals. Pestallozzi (1746–1827) believed that doing leads to knowing. He advocated the object method, with students proceeding from the known to the unknown and the simple to the complex and saw the potential of practical studies as content. Froebel (1783–1852), a German theorist, believed that activity precedes thinking and that education should begin with doing. He proposed, then, that purposeful doing evolves from impulse activity, that handwork is at the center of education. This thinking influenced elementary education movements featuring activity-based learning and technology education curricula with emphasis on discovery and exploration.

Cygnaeus (1810–1880) was acquainted with the writings of Pestallozzi and Froebel and their advocacy of learning by doing. As a result, Cygnaeus started educational Sloyd in Finland; this movement is known for its project-centered, constructive activities for all grade levels. The purpose of Sloyd was to retain attitudes, knowledge, and skills that were giving way to factory work and urban living. Sloyd was intended to be cultural-liberal and not vocational in its purpose.

Calvin Woodward provided a transition between formal disciplines and progressivist philosophy by promoting manual training as an essential part of education. Woodward established a manual training school with a general education focus: "The manual training school is not mere workshop; the head is to be trained even more than the hand. Specific trades will not be taught; the tool-education will be liberal, extending impartially through all the shops" (Woodward, 1887, p. 6). Brown (1977) argued that manual training did not influence development of industrial arts. Instead, industrial arts was the product of the progressivist movement. Current curricular debates regarding the role of tool skill development in technology education curriculum reflect this tension.

Major curriculum efforts have been rooted in human development theory. In the Maryland Plan of the 1960s, Maley used human-needs analysis "to identify appropriate methods for teaching" (Colelli, 1985, p. 3). The Maryland Plan was a student-centered curriculum for junior high school students. It was developed around anthropological units dealing with processes, materials, organizations, and occupations associated with past technology; modern industry units, line production, research and experimentation, group project, technical developments; and future-oriented activities for solving problems affecting humankind. *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) focused on human adaptation and technology as four areas of human endeavor: communication, transportation, construction, and manufacturing. These systems, or content organizers, were dominant in technology education beginning in the 1970s. Technology education curriculum that focuses on the ways people extend their capabilities, adapt to environments, and explore ways to meet specific needs and wants reflects this theoretical focus.

Some curricula focus on social problems and opportunities rather than individual human needs and development. Social emeliorism, for instance, is a curriculum theory that focuses on social change, where students are the future of society and should be prepared to plan and implement ways to change the society. The curriculum focus is on social problems, typically chosen by the students. The following technology classroom scenario is a hypothetical example of social emeliorism:

> The bell rings. Students are seated conference style in their Technology Assessment class. The technology teacher begins by asking the students what technology issues have they selected to research and present to the class. Bryan mentions the industrialization of Chinese cities and the resulting pollution. Jen cites the recent concerns regarding global warming and the recent political debates on this topic. Emilio discusses the issues surrounding the development of defense missiles and their range capabilities. Discussion takes place between teacher and students concerning how to assess impacts and consequences of these selected technological issues. Students then decide how they want to be graded on this unit.

Social emeliorism suggests that social concerns and impacts are the basis for technology studies and guide the selection of content and activities. Curriculum content may change as social concerns and world conditions change.

Technology education teachers' philosophical and theoretical base influence the way they implement curriculum and deliver instruction: "A curriculum is a plan for classroom instruction that integrates philosophy with action" (Kirkwood, Foster, & Bartow, 1994). Thus, the curricular and instructional decisions made by technology teachers are rooted in a personal philosophy. As Thut reveals, "What a man really believes . . . is frequently more clearly revealed in what he teaches the children than in what he professes in his public statements" (Zais, 1976, p. 105). What one believes to be essential teaching and learning goals, the role of knowledge and education, and nature of the learner grows out of one's philosophy, making philosophy a significant piece for curriculum decision-making and for the development of curricular goals, criteria, and content. Articulating one's philosophy is a precursor to designing and implementing curriculum for technology education.

DEFINING YOUR PHILOSOPHY

A teacher's personal philosophy concerning the study of technology, or any other school subject, develops over time because an individual's acquisition of knowledge and life experiences contribute to that philosophical position. Further professional training and educational experiences may reinforce or challenge philosophical positions. Ultimately, your personal philosophy regarding the study of technology reflects your belief system and what you value in the education of students. Your philosophy, however, may or may not be compatible with your school system's philosophy or their curriculum emphasis.

Philosophy could be imagined as a screen through which curriculum, instructional strategies, and assessment are sifted. The more well defined a teacher's personal philosophy, the more the sifted grains of curriculum and instruction are aligned with philosophy. Likewise, assessment is similar in grain size and in alignment with the other curricular grains.

How do you begin to define your personal philosophy? Posing fundamental questions and reflecting on the responses provide the elements of a philosophy. Questions to reflect on and possible responses include:

- What do I mean by technology? (artifacts, processes, human innovation, modification of nature)
- What is the role of education today? (preparing tomorrow's citizens, developing an educated workforce)

- What do I value in technology education? (content, process, critical thinking)
- Who should study technology? (all students, interested students, future engineers and technicians)
- What should students learn in technology education classes? (the scope of technology, problem solving)
- What is my role as teacher in the laboratory-classroom? (instructor, facilitator, mentor)
- What do I assess in instruction? (procedural knowledge, fundamental concepts, projects)

Your educational philosophy and personal "screen" for technology teaching and learning will emerge from the responses to these and similar questions. The following are hypothetical examples of philosophies that technology teachers may espouse:

Example 1. I believe the role of education is to prepare students to have the necessary thinking capabilities and skills to contribute to our information society. Technology education is a school subject that develops critical thinking, problem-solving, and reflective thinking. Students should develop skills such as computer-aided drawing, fabricating materials using hand tools and power equipment, and communicating what they have learned using various media. The curriculum should provide hands-on, minds-on experiences of increasing complexity. Students will learn technology best by engaging in team challenge activities, using modular instructional units, and doing computer simulations.

Example 2. Education should engage students in technological issues and problems facing this complex society. Students need to understand how we shape technology and how technology, in turn, shapes us. Students should graduate with an ability to address technological issues in a meaningful way. Classroom experiences should also provide opportunities for students to challenge prevailing notions, test their ideas, debate issues, and engage in research to ferret out misconceptions about technology. Students should know and understand that technology is not value-free; they will be making numerous decisions concerning technology that are value-laden and have significant consequences. The technology education curriculum should focus on timely issues of relevance to students. Students should be able to select issues and research them. Interdisciplinary instruction, cooperative learning, case studies, and seminars are the preferred instructional approaches. Students are assessed according to their presentation and investigation of the issues at hand.

Example 3. Education must prepare all students for participation in a technological society. Technology education should address the nature and scope of technology, the relationships between technology and society, design and its attributes, content and skills associated with creating, using, managing, and assessing technology, and various predominant technologies (ITEA, 2000). Students should have formal experiences that contribute to an increasing understanding of technology that contributes to their technological literacy. Upon graduation, students should have a level of technological literacy that enables them to make responsible decisions concerning technology, use technology wisely, and adapt with changing technologies. Students will develop technological literacy through collaborative learning, design brief activities, participating in simulations, becoming students of inquiry, and engaging in research and experimentation.

In Example 1, the philosophical position reflects social efficiency, since the role of technology is to prepare a productive citizen. The curriculum guided by this philosophy is process-oriented, with emphasis on the development of mental processes. In Example 2, social emeliorism is the underlying school of thought. Content is not derived by the teacher; the students determine what issues should be studied. Student experiences are highly interactive, learning via the presentation and testing of ideas with each other. Example 3 reflects the emphasis on social efficiency in standards-based instruction. Requisite for all students, technology education has a content-orientation and a literacy goal. Each of these positions reflects different truths and values about technology. Each philosophy translates into different instructional strategies selected by the teacher in order to orchestrate learning in subtly predetermined ways.

SELECTING INSTRUCTIONAL STRATEGIES

Instructional strategies may be teacher-directed or student-centered, content or process-oriented, and individual or group-focused. The results of instruction may be open-ended, with many solutions or outcomes possible: "Ultimately, choice of curriculum theories and designs rests with the classroom teacher. Whatever teachers believe tends to show up in the kinds of activities they select for students" (Zuga, 1993, p. 19). Alternatively, instructional results may be closed-ended, with one correct response for all students. **Figure 3-1. Instructional Strategies and Underlying Philosophical Positions** suggests some associations between philosophies and instructional strategies. While the strategies are not exclusive to each philosophical position and curriculum theory, the strategies listed may be more commonly aligned with each position that is presented in the same column.

Figure 3-1. Instructional Strategies and Underlying Philosophical Positions.

Philosophical Positions		
Human-Centered Philosophies	Earth-Centered Philosophies	Other-World Philosophies
Educational Theory		
Pragmatism, Progressivism	Positivism, Naturalism, Realism	Religions, Transcendentalism, Idealism
Curriculum Theory		
Human Development	Social Efficiency	Social Emeliorism
Curriculum Focus		
Processes, Individual growth	Standards, Outcomes	Liberal arts, Basics, Classics
Curriculum Rationale		
Social and individual needs Social learnings Social activity is content Developmental tasks	Function as productive citizen Activities in form of competencies Content sequence based on objectives	Intellectual and moral development Formal knowledge acquisition Taxonomies, Structures for knowledge
Instructional Strategies		
Discovery, Inquiry, Experimentation Cooperation and collaboration Interdisciplinary approach Design and problem-solving	Using modular instruction Web-based instruction Student competitions Community experiences	Concept-based Community experiences Interdisciplinary approach Socratic approach

In **Figure 3-1. Instructional Strategies and Underlying Philosophical Positions,** human-centered philosophies, particularly the connections between philosophical position, educational theory, curriculum theory, focus, rationale, and instructional strategies, are purposeful rather than incidental. What the teacher believes is real, true, and good is embedded in his or her decisions regarding instructional strategies. Although the teacher may be comfortable with more than one philosophical position and curriculum focus, he or she will tend to reflect one position more than the others. The technology teacher whose philosophical position is primarily human-centered may be inclined to implement a curriculum that is process-oriented and focuses on development of the individual. This teacher would be likely to use design challenges, teaming, research and experimentation, and portfolio development as preferred instructional strategies.

Teachers who are influenced by earth-centered philosophies and social efficiency will focus on developing students into productive citizens and preparing students to meet given outcomes. Their curriculum will be content-based and designed to address key objectives, standards, or proficiencies. Earth-centered teachers may be more inclined to deliver instruction using a modular approach, Web-based instruction, or student competitions.

Technology teachers who reflect other-world philosophies may be more focused on acquisition of formal knowledge and knowledge as the basis for social change. These teachers may be more inclined to use lectures, a Socratic approach, and interdisciplinary instruction in their classroom.

SUMMARY

Each technology teacher draws upon his or her belief systems to make curriculum and instructional strategy decisions. The philosophical positions represented by these beliefs may be implicit or well articulated. Clearly, understanding the historical philosophical bases for technology education helps teachers to understand how various beliefs have evolved. Curriculum foundations, such as philosophical inputs, theory-base, rationale, and criteria, influence the type of instructional strategies that are implemented in the technology laboratory-classroom. While such decisions are highly individual, they are not arbitrary. Instead, belief systems steer an individual technology teacher toward some instructional strategy preferences, such as inquiry and design, as opposed to others, such as the Socratic approach or concept-based approach.

Defining your personal philosophy for technology education enhances your curricular and instructional decisions. Articulating what is real, what you believe to be true, and what you value positions your philosophy as a foundation for teaching and learning. Using your philosophy strengthens the connections between what you know, do, and believe as it is conveyed to students in your classroom. Finally, reflecting on your philosophy will enrich your teaching and remind you of what is truly important to you as a technology teacher.

DISCUSSION QUESTIONS

1. How have your life experiences shaped your technology education philosophy?
2. Which philosophy reflects your curriculum orientation? Why? How?
3. How does philosophical foundation influence technology education curriculum and instruction?
4. Which educational philosophies are most controversial today? Why?
5. Select a philosophical position other than your own. What would be your major claims?

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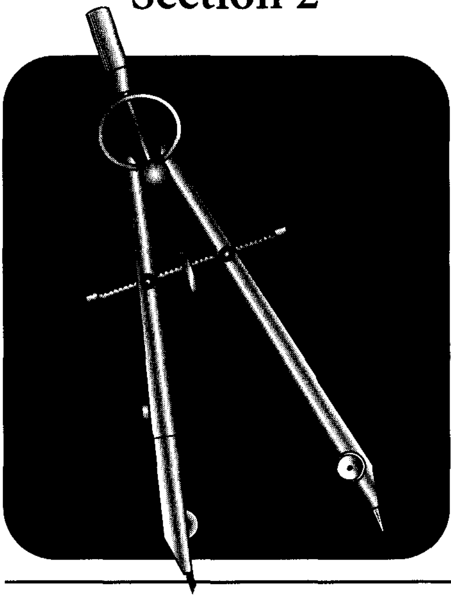
Section 2



INSTRUCTIONAL STRATEGIES FOR TEACHING TECHNOLOGICAL LITERACY

Section 2 is designed to provide an overview of various instructional strategies that are available and have been successful for the technology teacher. The content of technology education can be taught from several vantage points. Each chapter is designed to define and describe a specific instructional strategy in technology education.

Chapter Four, Concept Learning in Technology Education, examines the importance of teaching concepts in technology education. Chapter Five, Interdisciplinary Approaches to Teaching Technology Education, defines the importance, reasons, and examples of how to bring in other disciplines when teaching technology education. Chapter Six, Teaching Social/Cultural Impacts in Technology Education, introduces the need and importance of teaching the impacts of technology from a social/cultural viewpoint. Chapter Seven, Design and Problem-solving in Technology Education, discusses the methods and procedures for incorporating design and problem-solving into the technology education classroom. Chapter Eight, Inquiry in Technology Education, defines the inquiry process and shows how inquiry can be successfully used in the technology education classroom. Chapter Nine, Cooperative Learning in Technology Education, addresses the importance of and suggestions for including cooperative learning in the technology education classroom. Chapter Ten, Web-based Instruction in Technology Education, introduces the importance and methods of designing Web-based instruction in the technology education classroom. Chapter Eleven, Using Modular Environments in Technology Education, introduces modular technology laboratories and how they can best be used in the technology education classroom. Chapter Twelve, Student Competitions in Technology Education, looks at the need for and methods used to bring student competitions and challenges into the technology education classroom. Chapter Thirteen, Using Community Experiences in Technology Education, addresses the need and importance of including community experiences when teaching technology education. All of these chapters also include a connection to the *Standards for Technology Literacy: Content for the Study of Technology* (ITEA, 2000) by showing how each individual instructional strategy relates to differing components of the *Standards*.

Concept Learning in Technology Education

Chapter 4

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INTRODUCTION

To consider concept learning simply an approach or a teaching strategy is not an accurate portrayal of what is, indeed, the central goal of education. All good teaching, regardless of the strategies used, seeks to develop deep understanding in students—in other words, the ability to use the concepts that underpin and drive the disciplines being studied. "It would surely be agreed by all investigators of learning processes that 'conceptual learning' as opposed to other, presumably simpler, forms of learning, constitutes by far the major portion of the learning associated with what is supposed to go on in schools" (Gagne, 1966, p. 81). We operate in a conceptual world that we come to understand through a variety of informal and formal experiences throughout our lives. The ability to communicate conceptually helps us to simplify and organize our environment and interact effectively with others (Martorella, 1972).

PURPOSE

The purposes of this chapter are to (a) define the term *concept,* (b) explore the conceptual framework that supports the study of technology, (c) suggest ways that technology educators can facilitate concept learning in their classrooms, and (d) examine the assessment tools that are most appropriate for measuring concept attainment. A case will be made to support the notion that teaching for concept learning is, in its primary sense, teaching for understanding within a content domain. An attempt will be made to show how a variety of instructional strategies can be used to help students achieve learning with understanding.

WHAT ARE CONCEPTS?

Countless definitions of the term concept can be found, ranging from simple to sophisticated. By examining these definitions it is possible to construct a shared understanding of the term. In the simplest form, we might refer to concepts as the "big ideas" that help to describe the object or phenomenon under study. Moore (1998) notes that concepts are essentially abstractions used to categorize either concrete objects (e.g., animal, chair, camera) or conditions or processes (e.g., confused, efficient, manufacture) in ways that help us organize and make meaning of our world. A concept, according to Martorella (1972), "may be thought of as a category of experience having a *rule* which defines the relevant category [and] a set of *positive instances* or *exemplars* with *attributes*" (p. 7). The critical attributes of a concept enable us to describe and distinguish its identifying features; it is the attributes of concepts that people acknowledge when they communicate meaningfully about their world. More prescriptive definitions of the term, such as the preceding one, suggest the means by which concepts are to be taught.

Yost (1988) expanded the definition of the term by stating that concepts, in addition to helping us classify objects or conditions with shared attributes, must have some *applicability.* That is, some tangible benefit or use must be deemed for the concept that is learned. Perhaps the most significant use to which concepts are applied is in helping us acquire and retain large bodies of subject matter. Human beings are capable of assimilating only very limited amounts of discrete information, and do not retain that information unless it is used frequently or overlearned (Ausubel, 1966). As shall be explored in more detail, concepts provide the mental maps that enable learners to examine and categorize new ideas.

Moore (1998) considers learning to be hierarchical, with facts comprising the lowest rung in the hierarchy, concepts and principles the second rung, and thinking skills the top or penultimate rung. Martorella (1972) suggests a similar model. In his schema, concepts represent "fact clusters in a special interrelationship" (p. 15), and generalizations and theories result when related concepts and interrelated facts are combined.

The literature on teaching and learning contains a variety of terms that are used interchangeably, including *concept, conceptual scheme, organizational thread, fundamental idea,* and so on (Novak, 1966). In the end, it may be less important to establish a universally recognized definition of the term *concept* than to determine what strategies have proven to be most effective in helping students develop the fundamental understandings that have been deemed necessary for successful existence.

The psychologist Jerome Bruner is considered by many to be the developer of the concept attainment model of teaching (Joyce & Calhoun, 1996). His contributions to the education literature on this topic served to emphasize the importance of understanding the *structure* of a discipline, in order to better see how different pieces of information are related within that disciplinary framework: "The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer" (Bruner, 1961, p. 12). Bruner said that transfer is the "heart of the educational process" (p. 17); many believe that the ability to apply information in new contexts (i.e., learning transfer) is the key indicator of having learned with *understanding* (Mansilla & Gardner, 1998).

An attempt has thus been made to expand this discussion beyond the question of concept learning to a broader discussion, more reflective of recent literature, about teaching for structure and understanding. According to Wiske (1998), four key questions must be addressed in a "pedagogy of understanding" (p. 61):

- What topics are worth understanding?
- What about these topics needs to be understood?
- How can we foster understanding?
- How can we tell what students understand?

Stated differently, a pedagogy of understanding identifies what concepts should be taught, how they should be taught, and how student learning of the concepts can best be assessed. These questions are addressed in the sections that follow.

WHAT CONCEPTS SHOULD BE TAUGHT?

What Bruner referred to as the structure of a discipline is manifested in attempts to identify the fundamental ideas of that discipline (Novak, 1966). Novak and Bruner were both participants in a conference on learning held at Woods Hole, Massachusetts, in 1959. The 35 participants of that conference, funded by the National Science Foundation, were in agreement that "the best minds in any particular discipline must be put to work on the task" of determining a curriculum based on the underlying structure of the subject matter (Bruner, 1961, p. 19). Since that time, curricular standards and frameworks have been developed by teams of disciplinary experts and educators for nearly every subject within the typical school program (including mathematics, science, English, art, and technology). All represent consensus documents, written over extended time periods and with extensive input from a variety of sources. They also share some characteristic features:

> The curriculum standards and frameworks now being developed emphasize the need for students to make sense of key concepts in the disciplines, develop intellectual dispositions and habits of mind associated with inquiry, construct their own understandings rather than merely absorb the knowledge created by others, and see connections between what they learn in school and their everyday lives. Given the focus on understanding, the new standards call for teachers to make judicious selections of curriculum content, to be more clear about their purposes or goals, and to make assessment rooted in performance more integral to the teaching-learning exchange. Superficial coverage of overly broad content and multiple choice tests that feature recall of information are not viewed as virtues. (Perrone, 1998, p. 25)

The publication of the *Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association [ITEA], 2000) was a breakthrough event for the field of technology education. The standards for technological literacy and the *National Science Education Standards* (National Research Council [NRC], 1996; see also American Association for the Advancement of Science [AAAS], 1989) address the importance of including technology in the modern curriculum and provide a response to the question "What topics are worth understanding?" The ITEA *standards* are organized into five thematic chapters containing a total of 20 broad topics or standards. Each standard is then broken down into a series of benchmarks, organized by grade bands (K–2, 3–5, 6–8, 9–12). These benchmarks provide the conceptual framework that forms the basis of technological literacy.

Take, for example, Standard 1, Benchmark A: "The natural world and human-made world are different" (ITEA, 2000, p. 24). This benchmark mirrors a concept contained within the science education standards (NRC, 1996) for grades K–4, which states: "Some objects occur in nature; others have been designed and made by people to solve human problems and enhance the quality of life" (p. 138). This is a big idea—a fundamental concept in both technology and science—and young students' understanding of this concept will be demonstrated by their "abilities to distinguish between natural objects and objects made by humans" (NRC, 1996, p. 135). According to the prescriptive definition of a concept that we examined earlier, the teaching of this concept would involve stating the big idea, providing a rule or rules by which students would distinguish natural from human-made objects, and providing or soliciting examples of each. In this way an organizing framework has been started. Over time, students move beyond simply categorizing objects as natural or human made. They begin to understand that science is the study of the natural world and technology is the study of the human-made world, and that scientific inquiry and technological design are the basic processes used. They might also understand, through exposure to multiple examples, how technology and science depend upon and inform one another.

The *Standards* provide the list of topics that have been deemed worthy of understanding within the discipline. The benchmarks address the question of what must be understood about these topics. Each benchmark literally represents a concept or fundamental idea. Because any number of specific facts and strategies might be employed to help students understand and assimilate these concepts, the technology teacher must make significant decisions about how best to teach for understanding. This challenge is addressed in a general way in the next section.

HOW CAN CONCEPT LEARNING BE FACILITATED IN TECHNOLOGY EDUCATION CLASSROOMS?

The literature on concept learning and teaching for understanding very rarely contains either a discussion of, or examples from, technology education classrooms. One of the reasons why technology educators may reference the works of John Dewey and other progressive educators of his era is that in that body of literature we find specific mention of the skills of craft, industry, and the human endeavor. In the modern parlance, we consider these the types of knowledge and skills necessary to make one technologically literate.

It is also possible to glean considerable insights from the literature dealing with science education and education at large. Current theories of learning draw heavily upon the ideas of early theorists like Pestalozzi, Herbart, Froebel, and Dewey (Perrone, 1998). DeBoer (1991) points out that the persistence of these ideas gives them a legitimacy we should not ignore. For example, Dewey and others advocated that instruction should start by recognizing what students already know and understand; should incorporate direct, hands-on experiences that engage all the senses; and should be socially relevant to the lives of learners if it is to be meaningful (DeBoer, 1991). The same threads are woven through the modern literature on teaching for understanding.

Education is at the mercy of the political and popular agenda, however. Attempts to develop more progressive curricula in science and mathematics, much of it funded by the National Science Foundation in the 1960s, "floundered and faded into the 'back to the basics' movement of the seventies and eighties" (Perrone, 1998, p. 23), which resulted in curricula that were viewed as "teacher proof," less engaging, and more focused on rote learning. Perrone claims that current conditions "give some cause for hope that present efforts may succeed where earlier progressive movements fell short" (1998, p. 24). On the other hand, the current support for neo-progressive instructional approaches appears to be most prevalent among educators themselves and is not consistent with the forces of the accountability testing movement (this issue is discussed in more detail in the next section).

Caine and Caine (1991) use navigation as a metaphor to describe the difference between superficial learning (or rote memorization) and learning with understanding. Superficial learning is like following a route that takes us to our destination without enhancing our familiarity with our surroundings. We could probably find the destination again, but only by taking the same route. Understanding, on the other hand, is akin to establishing a map. Mental maps, like geographic ones, enable us to successfully navigate new surroundings (material) because we have a general familiarity with the area. When encountered, the new information is examined to determine into which conceptual neighborhood it fits. The ability to place ideas and facts into the context of a conceptual map or framework facilitates retrieval and use of that information in unfamiliar contexts (Donovan, Bransford, & Pellegrino, 1999).

Brandt (1998) identifies several features of "powerful learning." By building upon what they already know, students construct increasingly complex conceptual understandings. While people learn what is personally meaningful to them, learning is enhanced through social interaction. Learning is developmental. Novices, regardless of age, require more concrete (as opposed to abstract) instruction.

HOW CAN WE BUILD UPON WHAT STUDENTS ALREADY KNOW?

The first premise of teaching for understanding is that we must identify what, and how, students think about the topic being studied and then build upon that conceptual base. Bransford, Brown, and Cocking (1999) refer to this process as "progressive formulation," because it begins with the ideas the students have brought into the classroom and gradually enables these ideas to become formalized. In order to accomplish this goal, teachers must incorporate classroom activities and conditions that uncover student preconceptions. Frequent, informal assessments and the use of questioning techniques help "make students' thinking visible to themselves, their peers, and their teacher" (Donovan et al., 1999). Cognitive mapping is an exercise that can also be used to assess existing levels of understanding.

Once identified, this antecedent knowledge must then be shaped in such a way that acquisition of new concepts is facilitated. Ausubel (1966) identified what he called the "manipulable variables" of the existing cognitive structure. These include (a) the availability of relevant ideas to which new information can be anchored, (b) the extent to which these existing ideas are discriminable from the new information to be learned, and (c) the clarity and stability of the existing structure. The first variable indicates that there must be a sufficient backdrop of factual knowledge upon which learning for understanding can be built. If we accept the hierarchical view of learning, then it is organized groupings of facts that develop into the conceptual understandings that enable us to master a discipline. Teachers can enhance this variable through the use of definitions, examples, and metaphors. The second and third variables suggest that teachers can help students develop functional mental maps that enable them to make sense of new information. Brain research (discussed in Chapter 2) confirms that the human brain naturally seeks out connections between and among ideas: "The brain is designed as a pattern detector. Our function as educators is to provide our students with the sort of experiences that enable them to perceive the 'patterns that connect'" (Caine & Caine, 1991, p. 7).

How is this accomplished? Donovan et al. (1999) and others believe that this type of integrative learning can only occur when fewer topics are covered in greater depth. This learning involves examining the same concept using a variety of examples in a variety of contexts, while at the same time providing a foundation of factual knowledge:

> Teachers need to use a great deal of real-life activity, including classroom demonstrations, projects, field trips, visual imagery of certain experiences and best performances, stories, metaphor, drama, and interaction of different subjects.... Success depends on using all of the senses and immersing the learner in a multitude of complex and interactive experiences. Lectures and analysis are not excluded, but they should be part of a larger experience. (Caine & Caine, 1991, p. 86)

Integration of learning experiences across disciplines (see Chapter 5) can expand the contexts in which learning occurs, thus increasing the possibility of learning transfer. Contrary to the way that many subjects are structured in the schools, learning for understanding is likely also to extend across grade levels, as fundamental concepts are revisited in increasingly sophisticated ways (Donovan et al., 1999).

Structuring the Learning Experience for Understanding

A fundamental debate is being waged over the degree to which learning should occur in a receptive mode versus a discovery mode. The former is a teacher-centered approach in which the teacher structures and delivers content to the students. Discovery learning is student-centered, and operates from the premise that the learner will only internalize content that he has discovered independently. This debate is pertinent to the current discussion for a number of reasons. First is the question of efficiency. Teacher-centered reception learning requires less time to deliver more information. It is not as likely, however, to enable students to develop deeper conceptual understandings, and may be less appropriate for novice learners, who typically require more concrete, hands-on representations. Discovery or inquiry learning is at the heart of the kind of deeper exploration referred to in the preceding section. Ultimately, "both reception and discovery learning can each be rote or meaningful depending on the conditions under which learning occurs" (Ausubel, 1966, p. 158).

Making Learning Experiences Meaningful

One of the features of powerful learning identified previously is that people learn what is personally meaningful to them. Thus, regardless of the instructional approach used, if the topic is interesting and meaningful to students, the motivation to learn is presumably in place. Progressive educators such as Dewey felt meaning would be found in topics that were socially relevant for the time and place. Wiske (1998) refers to these as "generative topics"—ones that relate to the everyday lives and concerns of students. Relevance is, however, relative; potential meaningfulness varies depending on the learner. Both Ausubel (1966) and Wiske (1998) suggest, too, that meaningfulness stems from more than just choosing relevant topics. In addition, the topic should be central to the discipline, relatable to the learners' existing structures of knowledge, and designed to "involve students in continuing spirals of inquiry that draw them from one set of answers to deeper questions and that reveal connections between the topic at hand and other fundamental ideas, questions, and problems" (Wiske, 1998, p. 63). Another important feature of powerful learning experiences is their social aspect. Cooperative learning (see Chapter 9) can be used to provide important social relationships, which assist in the development of meaning.

Extending the Learning Experience

A constant tension exists between the need for a solid foundation of factual information and the need for engaging students in inquiry-based situations that are more reflective of the world outside school. Bransford et al. (1999) note that students spend only 14% of their time in school, compared to 53% of their time in the home and community (p. 135). Thus, a failure to create learning experiences that are linked to students' outside experiences is a failure to tap into the extended opportunities for understanding important concepts. Bruner (1961) suggested that the challenge to teachers is to present the fundamental knowledge base of the discipline while allowing for meaningful opportunities for student discovery. This could involve the use of "preliminary performances or subperformances in order to develop understanding of ideas and processes" (Wiske, 1998, p. 74), time spent in "deliberate practice" that includes coaching on optimal performance (Bransford et al., 1999, p. 50), followed by a culminating performance in which students synthesize what has been learned through this sequence of activities.

It is probably safe (and even important) to assume that performances within a technology education classroom will involve the use of tools, materials, and processes. Ausubel (1966) has suggested that younger and novice learners can more readily discover the criterial attributes of concepts when they are able to manipulate objects at a sub-verbal level. This manual exploration can lead to abstract understandings. Anecdotally and intuitively, we may believe that the hands-on experiences characteristic of technology education classrooms do contribute to concept learning, but additional research is needed, particularly with respect to the concepts identified in the *Standards* (ITEA, 2000). Technology teachers must also recognize that many hands-on activities fail to contribute to student understanding because they are not explicitly focused on important concepts (Custer, 1994; Wiske, 1998).

HOW CAN WE EVALUATE CONCEPT LEARNING?

The development of national standards has enabled many disciplines to achieve a welcome consistency in curricular frameworks across school sites. Moreover, these frameworks are based on input from both content and instructional experts. However, this largely positive outcome also has what Thompson (2001) calls its "evil twin": the widespread adoption of large-scale, high-stakes testing. In and of itself, testing for content knowledge can provide beneficial feedback. But in many states, due to the exigencies of time and money, the measures used only examine part of the picture, yet are considered representative of the whole. These tests typically focus on terms or facts—surface knowledge—rather than on deeper conceptual understanding (Martorella, 1972; Bransford et al., 1999; Donovan et al., 1999; Caine & Caine, 1991). Such measures are inconsistent with the instructional approaches adopted by those who teach for understanding. Given the misalignment between what is taught and what is assessed, it is not possible to accurately gauge what is being learned (Bransford et al., 1999). As Moore (1998) states, "Knowing the label or name does not guarantee an understanding of the concept" (p. 140). Nor do interest and engagement, per se, equate to conceptual understanding (Donovan et al., 1999).

Caine and Caine (1991) note that the emphasis on testing for surface knowledge (what they call "route" learning) can eventually shut down students' ability to create more complex mental maps:

> Maps constitute an internal organization of information and always contain much more than the information packaged in a lesson or textbook. When every step is predetermined, students simply do not have the opportunity to organize information adequately. Moreover, they

> frequently fail to see the relevance of such information or a direct need for it. Hence they tend to memorize rather than to think. A second reason is that intrinsic motivation is often sabotaged by the imposition of a strong extrinsic system of motivation. (Caine & Caine, 1991, p. 45)

Another negative by-product that can result from relying on tests of surface knowledge is that the limited capacity of most students to retain information is essentially wasted on trivial facts. "Much more can obviously be apprehended and retained if the learner is required to assimilate only the *substance* of ideas rather than the verbatim language used in expressing them" (Ausubel, 1966, p. 162).

To counteract the shortcomings of end-of-year, high-stakes testing, teachers must recognize the importance of ongoing assessment and create "assessment-centered environments" (Bransford et al., 1999, p. 129; see also Wiske, 1998). Assessments should be "learner-friendly," providing students with opportunities to revise and improve their thinking, and help them see their own progress over time (Donovan et al., 1999, p. 21). This type of formative assessment is critical for increasing student learning and for enabling learning transfer (Bransford et al., 1999).

Some authors suggest that a student who truly understands a concept will be able to apply that understanding in new or unexpected situations (Caine & Caine, 1991; Mansilla & Gardner, 1998). Mansilla and Gardner (1998) call this the knowledge dimension of understanding, characterized by the ability of students to move beyond merely intuitive or reflexive thinking. With conceptual understanding also comes the ability to ask pertinent questions in the mode of inquiry of the discipline.

At a minimal level, testing for concept acquisition entails asking students to describe the concept by providing both its critical attributes and multiple exemplars. If educators wish to test for deep understanding they must look beyond the ability to identify definitions, rules, and symbols. Instead, students could be presented with a scenario whose solution requires gathering the right information, manipulating it in ways that are likely to lead to a satisfactory response, and devising and communicating the response using the language and methods of the discipline.

Evaluation in an assessment-centered classroom takes on a very different role than when it is viewed as merely a means to a final grade, or as a gateway toward promotion. Teachers and students alike recognize the important role assessment plays in enhancing learning, by providing feedback along with opportunities to revise previous work.

EXAMPLES OF CONCEPT LEARNING IN THE TECHNOLOGY EDUCATION CLASSROOM

Standard 20 of the ITEA *Standards* states: "Students will develop an understanding of and be able to select and use construction technologies" (p. 191). One of the concepts that a person who understands construction technologies will acquire is that the design of a structure is dependent on a number of variables, including its intended use, the materials available, the climate in which it will be built, existing laws or codes, and other factors. Benchmark A states: "People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools" (p. 192). Following is a simple series of examples to illustrate how the acquisition of this concept might develop over time.

The first-grade teacher began a unit on construction by reading the story of the *Three Little Pigs.* In this familiar story, each pig constructs a new home out of a different material, with vastly different results. After reading the story, the teacher asked the students questions like: Why did each pig select the material he used to build his house (straw, sticks, brick)? Why did the pigs need houses? Why do you think the bricks turned out to be the best material for the pig's house? Following this discussion, the teacher introduced the term "structure," and provided a simple definition for the word. She then asked students to think of examples of structures in their own communities. Students identified examples like "my house," "the school," and "our church." The teacher then repeated the definition of the term "structure" and, through prompting with the use of pictures, the students were able to identify additional examples such as bridge, monument, and train station.

A fourth-grade teacher hoped to expand his students' understanding about the design of structures as part of the class social studies unit on communities. He used as his guide Benchmark C: "Modern communities are usually planned according to guidelines" (p. 193). For homework, he asked his students to observe and write down as many examples as they could of structures that were necessary parts of their local community. The next day, the class generated a list of the different types of structures they had identified: houses, supermarkets, gas stations, libraries, schools, churches, museums, movie theaters, and more. With prompting, the students also determined that roads, sidewalks, bridges, parks, and other features were an important part of the community. The teacher showed a short video describing the roles various people play in the planning of communities and community structures, including architects, city planners, zoning boards, and engineers. The class decided that they would create a model neighborhood. Students were assigned different roles. One team of three students became the civil engineers who determined where to locate roads, bridges, sidewalks, and crosswalks. Another team of students became the city planners. Other students played the roles of architects and builders, who planned and created the various structures to be included in the neighborhood. Each builder had to apply to the city planners for a building permit. The planners then determined whether the size and location of the building was appropriate. Using boxes, paper, and a variety of other materials, students constructed their model neighborhood. Modifications were made while construction progressed as they considered concerns such as safety, convenience, and attractiveness of the neighborhood. Students were also asked to create essays describing the features of their model neighborhood and explaining why these features were included.

A high school technology education teacher wanted to engage her 11th- and 12th-grade students in an in-depth examination of the elements of structural design. Standard 20, Benchmark L served as the guiding concept: "The design of structures includes a number of requirements" (p. 196). Her students had already learned about basic residential construction techniques, zoning laws, and the use of computer-aided drawing tools. After some discussion about housing concerns in their city, including urban flight and the lack of affordable housing convenient to city services and shopping, the class determined that the design challenge they would pursue would be the rehabilitation of an abandoned building and lot located not far from the school and close to city transportation. They also determined that the structure to be designed for the lot would provide ten apartments for mixed-income residents, would incorporate features for greater resource efficiency, and would present an attractive, residential appearance. The students were assigned different planning tasks. One team, for example, researched the availability and cost of efficient plumbing fixtures, appliances, and windows. Another team researched the availability and insulating abilities of prefabricated structural units. A third team considered the space needs of different households, including families with children, single professionals, and the elderly. The fourth team examined siting and landscape features that would minimize heating and cooling loads on the building while maximizing safety of residents. Yet another team examined the zoning restrictions and building codes in place for the location in question. The various teams met regularly in a large group to discuss their findings, and to make decisions about the types of materials and design features they would incorporate into their structure. Finally, the teams were asked to prepare presentations showing sample designs and supporting detail regarding the topic they researched. For example, the fixtures and windows team members presented their product selections, describing reasons these selections were made and the advantages of their choices in terms of cost, efficiency, and function.

The teacher used a variety of evaluation strategies to assess the ability of students to consider and critically analyze design requirements of structures. For one task, students were asked to consider a new sports facility that had recently been built on their school campus. In an essay, they were asked to identify the two design criteria that they believed had been maximized in the design of the structure and to provide support for their views. In another essay, students were asked to identify the four most critical design criteria they would consider in the design of their own home and to suggest one specific strategy for addressing each criterion. Students were given a multiple-choice test covering specific factual content learned and also received detailed feedback and a grade on the design challenge completed in class.

Wiske (1998) describes two significant difficulties that teachers encounter when designing instructional experiences that lead to concept acquisition. First, teachers often have multiple goals, some of which do not center on student understanding of content. Learning to work as a member of a cooperative team, for example, is a commonly voiced goal of instruction in technology education classrooms. Another is the ability to follow directions. Although these are admirable goals, they do not necessarily promote deeper understanding of content, and may distract from the larger goal of concept acquisition. Second, when teacher understanding of content is limited, he or she can have a harder time identifying and articulating primary learning goals. This process is an essential part of teaching for understanding.

In the examples provided above, the teachers incorporated strategies recommended for teaching for understanding. First, they were able to identify the overarching concept or benchmark that would drive the activities. Supporting content and companion benchmarks (such as Standard 20, Benchmark N) were also identified. With the younger learners, the teacher introduced new terms and definitions and then engaged her students in identification of examples. Older students were asked to make observations and to incorporate previously learned material in an examination of a new challenge. In both cases, the students engaged in direct, hands-on experiences that supported the content being addressed. The challenges were purposefully selected for their social relevance and capacity to address content that was central to the disciplines under study. They also engaged students in deep learning experiences that were rich with opportunities for observation, questioning, and inquiry about the given topic.

In spite of the very student-centered approaches taken in these classrooms, the teachers obviously exert a great deal of professional judgment in structuring the learning environment for inquiry and engagement. The key word is *structuring:* building instructional experiences around a solid conceptual framework, identifying antecedent and new content that will support conceptual understanding, and conducting frequent informal and formal inspections of student understanding to assess the strength of the cognitive schema being built. In this way, over time, increasingly sophisticated levels of technological literacy can be achieved by all students.

SUMMARY

While the exact definition of concept learning may be difficult to identify, the application for technology education is not difficult to understand. This approach is a core teaching style in all disciplines. With the ever increasing level of technology in society, teaching concepts verses specific technology allows technology education to provide the technologically literate citizens needed to survive and advance in a technological society. The application of this approach has never been easier with the publication of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000); the content for teaching concepts in technology education has been identified by grade level and content areas. This chapter has been designed to provide ideas on how to use the *Standards* and apply them using the concept approach for teaching technology education.

DISCUSSION QUESTIONS

1. What is the broad curricular significance of the publication of the *Standards for Technological Literacy?* How and why should classroom teachers use the *Standards?*

2. Some educators believe that deep understanding and transferable knowledge are only acquired when fewer topics are covered in greater depth. What reasons would you provide in support of this statement? What arguments might be provided to dispute this statement?
3. Research has shown that when topics are personally meaningful to learners, learning is likely to be enhanced. What features are characteristic of meaningful topics? What can you as a teacher do to help make lessons more meaningful to students?
4. What are the challenges inherent in devising evaluation tools that assess depth of concept learning? Identify a key technological concept, discuss how you might teach it, and describe how you would evaluate student acquisition of this concept.

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Interdisciplinary Approaches to Teaching Technology Education

Chapter 5

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Hail to the Skillful, cunning hand!
Hail to the cultured mind!
Contending for the world's command,
Here let them be combined.
—Calvin Woodward, 1887 (cited in Barlow, 1967, p. 36)

INTRODUCTION

As Woodward's axiom implies, it is counterintuitive for the study of technology to be segregated from the rest of the school curriculum, because technology is intertwined with nearly every aspect of our lives. At best, this practice is illogical. At worst, it perpetuates misconceptions about our technological world. With the study of technology rapidly becoming a significant component of science, social studies, and other school curricula, the profession has an unprecedented opportunity to explore and implement interdisciplinary instructional strategies appropriate to the study of technology.

The segregation of technology from other school subjects is grounded in cultural values placed on knowing and doing, dating to antiquity. Plato and Aristotle postulated that knowledge was separate from—and to be held at some higher level than experience—a cultural bias that remains to this day. But the idea of integrating praxis—the doing of technological activity—with *academic* subjects has been at the heart of educational experiments throughout the past century, and has been increasingly embraced over the past few decades.

Noted philosopher John Dewey was explicit in denouncing the separation of knowing and doing. In *Democracy and Education,* Dewey (1917) reasoned:

> The most direct blow at the traditional separation of doing and knowing . . . has been given by the progress of experimental science. . . . There is no such thing as genuine knowledge and fruitful understanding except as the offspring of doing. . . . Knowledge and power of

> explanation . . . cannot be attained purely mentally—just inside the head. Men have to do something to the things when they wish to find out something. (Chapter 20)

In the latter half of the 20th century, many of those who thought deeply about and experimented with the teaching/learning process have formulated learning theories that promote *contextualizing* ideas by grounding them in meaningful experiences. The theories of constructivism, situated learning, and experiential learning, for example, are widely accepted and support the idea of integrating relatively abstract ideas with technological problem-solving experiences. Constructivist theory suggests schema and mental models lend meaning and organization to ideas (Bruner, 1966). Constructivists believe students build their understandings of the world through active information processing. Situated learning theory (e.g., Brown, Collins, & Duguid, 1989; Greeno, 1988; and Lave & Wenger, 1990) holds that knowledge must be presented in an authentic context. Experiential learning theorists such as Rogers (1969) suggested learning occurs through direct confrontation with practical, social, personal, or research problems, and the most effective learning occurs when subject matter is self-initiated and deemed relevant by the student.

The ideals of these now-popular learning theories—that learning is best accomplished in the presence of mental models, schema for understanding, active information processing, authentic contexts, practical real-world problems, and personal relevance—are all attributes of the *technological problem-solving method* common in contemporary technological studies. Thus, contemporary learning theory strongly supports the implementation of interdisciplinary instructional approaches to technological studies.

PURPOSE

The purpose of this chapter is to discuss the instructional strategy of the interdisciplinary approach to teaching. The development of education has resulted in a separation of subjects in the school setting. Technology is not a "stand-alone" entity but rather is intertwined with nearly every aspect of our lives. Thus, an interdisciplinary approach to the study of technology is more logical than a segregated approach.

EARLY INTERDISCIPLINARY CURRICULUM MODELS IN THE PROFESSION

Throughout most of the last century, noted industrial arts/technology educators borrowed from these educational philosophies and learning theories in designing curricula that connected praxis and academics via an interdisciplinary instructional approach. Bonser and Mossman (1923) proposed an interdisciplinary industrial arts elementary school model in which hands-on activities were situated in a social/cultural context. Maley (1959) argued the point with a question: "Where else in the school is there the possibility for the integration and application of the mathematical, scientific, creative, and manipulative abilities of youngsters to be applied in an atmosphere of references, resources, materials, tools, and equipment so closely resembling the society outside school?" (p. 12). In formulating a curriculum model he called *The Maryland Plan,* Maley (1973) combined his ideas of interdisciplinary instruction with his belief that industrial arts activities should be developmentally appropriate. In describing the "culture complex," Olson (1973) suggested the industrial arts curriculum should explore—among others—the historical, economic, social, aesthetic, political, environmental, scientific, and industrial aspects of technology. In describing these terms, he wrote: "These are an invitation to integrated, correlated, and articulated study with other disciplines" (p. 10). DeVore's (1972) "Sphere of Universal Technological Endeavors" model depicted the interrelationships of technology with "social cultural elements" (p. 33). Savage and Sterry's (1990) "Interaction of the Domains of Knowledge and Human Adaptive Systems" model illustrates interactions among technology, science, humanities, formal knowledge, and natural environments (p. 10).

EDUCATIONAL REFORM AND NATIONAL STANDARDS

The incorporation of technological content into the school curriculum became a significant thrust of educational reform efforts of the 1990s. *Science for All Americans* (AAAS, 1989) catapulted technology into the mainstream of educational reform. Its chapters on "Science and Technology" and "The Designed World" legitimized the study of technology within the context of science and became a rationale for all future curriculum efforts that sought to connect the study of science and technology.

Concurrently, the national standards developed for science, mathematics, social studies, and technology education explicitly addressed the study of technology in an interdisciplinary context. "Content Standard E: Science and Technology" of the *National Science Education Standards* (NSES) for example, advocates that students develop "Abilities of Technological Design" (NRC, 1996). This section of these *science standards* describes a process very familiar to technology educators:

- Identify appropriate problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design. (pp. 165–166)

Similarly, "Thematic Standard #8: Science, Technology, and Society," of the *National Standards for Social Studies Teachers* (NCSS, 1997) stressed the importance of technological study in the *social studies* curriculum. Specifically, it says social studies teachers should "possess the knowledge, capabilities, and dispositions to organize and provide instruction. . . for the study of science, technology, and society" (Par. 1). It encourages students to trace the impact of science and technology in "agriculture, manufacturing, the production and distribution of goods and services, the use of energy, communication, transportation, information processing, medicine and health care, and warfare" so that they might understand "the way science and technology have influenced and have been influenced by individuals, societies, and cultures" (Par. 2). This *social studies* standard is eerily reminiscent of technology education literature when it proclaims the following: "By examining questions and issues raised historically and contemporaneously resulting from scientific inquiry and technological applications, learners can be better prepared to make informed decisions as citizens about individual choices and policy alternatives that face society" (Par. 3).

The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) reiterated what these earlier standards documents had already begun to make clear—technological study should be integrated with other disciplines and school subjects. Specifically, Standards #4—The Cultural, Social, Economic, and Political Effects of

Technology, #5—The Effects of Technology on the Environment, #6—The Role of Society in the Development and Use of Technology, and #7—The Influence of Technology on History, set the stage for interdisciplinary instructional strategies that connect technology education with the science and social studies curricula.

RELATED RESEARCH FINDINGS

Over the past four decades, researchers in industrial arts/technology education have identified various benefits of integrating technological content with other subject areas (Brusic, 1991; Champion, 1966; Childress, 1996; Downs, 1969; Ingram, 1966; Korwin & Jones, 1990; LaPorte & Sanders, 1995; Logan, 1973; Pershern, 1967). Likewise, hands-on activities in science education have been shown to enhance the learning process (Brooks, 1988; Cotton & Savard, 1992; Glasson, 1989; Mattheis & Nakayama, 1988; Roth, 1991, 1992, and 1993; Saunders & Shepardson, 1984).

International comparisons of mathematics and science education suggest the current approach to these subjects in the United States is not as effective as it might be. Of the 38 countries studied, the U.S. ranked 19th in achievement in 8th grade mathematics and 18th in achievement in 8th grade science (U.S. Department of Education, 1996). These and similar earlier findings prompted the National Science Foundation (NSF) to fund research and development projects that integrated technology education content and method with science and mathematics. These NSF projects included "Phys-Ma-Tech" (Scarborough, 1993); the "Technology, Science, Mathematics Integration Project" (LaPorte & Sanders, 1993, 1996); "Project UpDATE" (Todd, 1994); "Integrated Mathematics, Science, and Technology" (Loepp, 1999); and the "Children Designing and Engineering Project" (Hutchinson, 1999). Each of these projects resulted in curriculum and/or teacher in-service materials, most of which are described later in this chapter.

CONCEPTUALIZING INTERDISCIPLINARY INSTRUCTION

Those working to develop and implement an interdisciplinary approach to technology education should consider the different ways of conceptualizing interdisciplinary instruction. Jacobs (1989) provided a helpful set of "design options for an integrated curriculum" in which she described 10 different interdisciplinary curriculum models. Fogarty (1991, cited in Lake, 2002) extrapolated the following interdisciplinary instructional approaches from Jacobs' work:

Fragmented. The traditional model of separate and distinct disciplines, which fragments the subject areas.

Connected. Within each subject area, course content is connected topic-to-topic, concept-to-concept, one year's work to the next, and relates idea(s) explicitly.

Nested. Within each subject area, the teacher targets multiple skills: a social skill, a thinking skill, and a content-specific skill.

Sequenced. Topics or units of study are rearranged and sequenced to coincide with one another. Similar ideas are taught in concert while remaining separate subjects.

Shared. Shared planning and teaching take place in two disciplines in which overlapping concepts or ideas emerge as organizing elements.

Webbed. A fertile theme is webbed to curriculum contents and disciplines; subjects use the theme to sift out appropriate concepts, topics, and ideas.

Threaded. The meta-curricular approach threads thinking skills, social skills, multiple intelligences, technology, and study skills through various disciplines.

Integrated. This interdisciplinary instructional approach matches subjects for overlaps in topics and concepts with some team teaching in an authentic integrated model.

Immersed. The disciplines become part of the learner's lens of expertise; the learner filters all content through this lens and becomes immersed in his or her own experiences.

Networked. The learner filters all learning through the expert's eye and makes internal connections that lead to external networks of experts in related fields.

The work of Jacobs (1989) and Fogarty (1991, cited in Lake, 2002) points to the many options, nuances, and attending complexities—some obvious, others less so—that really must be considered when designing or implementing an interdisciplinary instructional approach to technology education. Technology educators and curriculum developers should identify an approach or a combination of approaches that they deem suitable for their situation and plan accordingly.

PLANNING INTERDISCIPLINARY INSTRUCTION

Whether the integration of content takes place only in the technology education course, or is orchestrated among several courses/teachers, careful planning is the key to successful implementation of integrated instruction. Administrative support is also critically important, particularly for those strategies that include more than one school subject/teacher. Teacher "teams" need common planning time, as well, which is typically scheduled by a school administrator. If no common planning times are provided during school hours, teachers on the "team" *will* need to meet before or after regular school hours to coordinate efforts. It is impossible to ignore the need to plan interdisciplinary instruction when teams are involved.

As noted earlier, considerable resources have been invested over the past decade—particularly by the National Science Foundation—to develop instructional materials that integrate technological content and method with other school subjects. Individuals and/or school systems need not—nor can they afford to—reinvent integrated instructional units. Rather, those planning to implement an interdisciplinary approach to technology education should begin by reviewing as many of the existing materials as possible. To assist with this process, a number of projects are briefly described in the "Approaches to Interdisciplinary Technology Education" section, along with information about where to locate the materials described. Teachers/schools may use these materials "as-is" or adapt them as they see fit—thus saving considerable time and resources.

While existing materials can provide a framework, specific instructional strategies will need to be agreed upon by all teachers involved. Success will depend largely on the commitment of all teachers involved. Alternatively, a single teacher (e.g., technology education teacher) may tackle an interdisciplinary instructional unit, but doing so successfully requires considerable creativity, knowledge, and careful planning.

ASSESSING INTERDISCIPLINARY INSTRUCTION

As should be the case for any assessment strategy, assessments of interdisciplinary instructional models should be predicated upon the initial goals and objectives identified. Too often, scores on pre-existing standardized achievement tests have been used to assess innovative instructional approaches. If the goal of a new interdisciplinary instructional unit were to improve achievement on such standardized tests, student scores on these tests would be an appropriate measure. However, since the goals of newly developed interdisciplinary instruction are likely to be different from those measured by pre-existing standardized tests, one should expect such ill-conceived assessments to yield indifferent or even negative results. In other words, it is critical that the validity of the assessment is established.

Most of the instructional materials developed for integrating technology education with other school subjects engage students in researching, designing, constructing, and evaluating solutions to technological problems. One might, therefore, assess the interdisciplinary instructional approach by examining student performance on those constructs (researching, designing, etc.). But other intended outcomes exist, as well. "Problem-solving ability," for example, is an often-stated goal of this type of instruction. The solutions (physical artifacts) developed by students may be helpful in assessing problem-solving ability, but using a "product" to evaluate a "process" is tricky business riddled with pitfalls. Student "portfolios" that document their ideation throughout the problem-solving process are helpful in evaluating problem-solving ability and could provide a means for assessing this aspect of the interdisciplinary instruction. Portfolios might also be helpful in assessing the extent to which the interdisciplinary instruction causes students to incorporate principles from other subjects such as science and mathematics.

Indeed, the assessment of innovative instructional strategies in general—and the integration of technology education with other school subjects in particular—have only recently begun to garner the attention they deserve. Because far more questions arise than answers, technology education teacher educators and researchers should assess new interdisciplinary instructional strategies with cautious determination.

APPROACHES TO INTERDISCIPLINARY TECHNOLOGY EDUCATION

No single best way to approach interdisciplinary technology education exists. The fact that the philosophies and structures of elementary, middle, and high schools vary considerably necessitates very different approaches at each of these three levels. Beyond that, the work of those such as Jacobs (1989), Fogarty (1991, cited in Lake, 2002), discussed earlier encourages the need for a variety of different approaches to interdisciplinary technology education.

In addition to "conventional" instructional materials, careful consideration should be given to the many state/national "technology" competitions that are held each year throughout the United States. Many of the most successful teachers use state/national competitions to motivate students. While most of these competitions are designed to be extracurricular, the unique flexibility of technology education programs often allows technology teachers to incorporate these competitions as a component of the regular curriculum. Chapter 12 further introduces competitions as a viable instructional strategy.

The limited space herein does not allow for thorough descriptions of the many interdisciplinary instructional approaches that have been implemented in the profession. What follows, therefore, is an annotated list of many of the interdisciplinary projects that have been conducted in the field, particularly those with published curriculum materials that the reader may obtain. Materials on the accompanying Web sites should be extremely useful to those planning to implement interdisciplinary instructional approaches to the study of technology. The following list is structured by school level—elementary, middle, and high school. For some additional listings, particularly for specific interdisciplinary technology education activities, see the ITEA Monograph, *Integrating Technology Education Across the Curriculum* (Sanders & Binderup, 2000).

Elementary-Level Approaches/Projects

Although elementary technology education is still sparse in the U.S., the K–5 standards in *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) provide insight into what interdisciplinary technology education at the elementary school level might become. Indeed, the elementary school provides one of the best opportunities for interdisciplinary work, since many elementary teachers routinely work in this mode. Obstacles include insufficient technology education backgrounds among most elementary teachers and their principals, as well as a curriculum that is already overflowing with content. That said, some of the most exciting interdisciplinary work in technology education is currently taking place at the elementary grade levels.

Project UpDATE developed 12 K–6 curriculum packages known as "Contextual Learning Units" (CLUs) for teaching integrated mathematics, science, and technology. The materials, which each relate to common elementary level readings, focus on design, technology, and problem-solving approaches. For example, *The Three Little Pigs* provides the context for a CLU on house construction in which students build models of houses to experiment with different construction materials/techniques (Todd, 1994).

Children Designing and Engineering developed instructional units for grades K–5 known as *TechEdge Topics.* These units apply a design and technology approach to real-world activities. They are intended to increase the scientific and technological literacy, capability, and responsibility of all students. *TechEdge Topics* are based upon subject matter from business and industrial settings (e.g., transportation, food, safety, and utilities) that young learners find particularly interesting and relevant. Each unit includes a guided portfolio, a technology education topic book, and a teacher's guide (Hutchinson, 1999). For more information on the World Wide Web, go to http://www.tcnj.edu/~cde/.

Craftsman/NSTA Young Inventors Awards Program challenges students in grades 2–5 to use their imaginations along with science, technology, and mechanical ability to invent or modify a tool. The tool, which students design/construct on their own, must perform a practical function. The two national winners (one from each grade level competition) receive a $10,000 U.S. Savings Bond each and the 10 finalists (five from each grade level) receive a $5,000 U.S. Savings Bond each (NSTA, 2002). For more information on the World Wide Web, go to http://www.nsta.org/programs/craftsman/.

Toshiba/NSTA ExploraVision Awards Program is a national competition for students in grades K–12 (in four divisions: K–3, 4–6, 7–9, and 10–12) that encourages students to "combine their imaginations with the tools of science to create and explore a vision of a future technology" (Par. 1). Students, working in small groups, select a technological device; explore what it does; how it works; and how, when, and why it was invented. They then project what that technology might be like in 20 years and convey their projections to others in writing and via a Web site (Toshiba, 2002). For more information on the World Wide Web go to: http://www.toshiba.com/tai/exploravision.

<u>*Middle-School Level Projects*</u>

In some ways, middle schools are best prepared for interdisciplinary instruction, since the vision for middle schools was predicated upon integrated subject matter and teaching teams (Vars, 1987). Middle school teaching "teams" are almost universally comprised of the "academic" teachers only (planning time is created when students are collectively scheduled into elective subjects during a single class period). Thus, one of the real keys to interdisciplinary technological studies at the middle school level is to convince school administrators to include technology teachers in the "teams." This is perhaps the most critical prerequisite for planning and implementing interdisciplinary instruction. The following project materials and competitions facilitate interdisciplinary technology education in the middle school.

Learning by Design developed learning modules built around engineering and design problems that promote the learning of essential concepts and processes in mathematics, science, and technology education. Based upon complex design problems, the modules integrate content from the different disciplines, focus on collaborative learning and doing, and foster reflection. Computer support provides an interactive problem-solving environment, information resources, and scaffolding for teachers. Diversity issues are addressed through the relevant realistic problems that are solved through cooperation and communication. For more information on the World Wide Web, go to http://www.cc.gatech.edu/edutech/projects/lbdview.html.

DESIGNS consists of six modules based on engineering projects intended as an alternative to traditional and discovery-based experiments for introductory physical science courses. Each challenge begins with student construction of a standard device (e.g., batteries, bridges, electromagnets, solar heating, and a gravity car). Students are challenged to optimize the performance of a variable that has a large range. Construction of the solutions takes relatively little time and the outcome is tested publicly. Students are asked to predict results of trials and explain the outcomes. The six modules are available from Kendall/Hunt Publishing Company under the title *Challenges in Physical Science* (Harvard-Smithsonian Center for Astrophysics, 2002). For more information on the World Wide Web, go to http://cfa-www.harvard.edu/cfa/sed/projects/designsinfo.html. and http://www.kendallhunt.com/.

World in Motion II is a multi-disciplinary curriculum for grades seven and eight. Over the course of eight weeks, students work together in engineering design teams through a six-phase design process, which includes setting goals; building knowledge; designing; building and testing; finalizing the model; and presenting the results. Students become engaged in an intense exploration of hands-on materials as they investigate the relationship between force and motion, the effects of weight and lift on a glider, data analysis and variable manipulation, and the importance of understanding consumer demands. Volunteers share their professional experiences in engineering, science, math, marketing, oral communications, and/or consumer research (Society of Automotive Engineers, 2002). For more information on the World Wide Web, go to http://www.sae.org/students/awimii.htm.

Integrated Mathematics, Science, and Technology is a two-year, middle school curriculum designed to facilitate the attainment of national mathematics and science standards. Students are expected to spend at least 40 minutes per day in each of the disciplines of math, science, and technology. The 7th grade modules are titled Wellness, Food Production, Waste Management, Energy Transformations, Manufacturing, and Forecasting. The 8th grade includes modules on the themes of Animal Habitats, Human Settlements, Systems, and Communication Pathways. Each module includes objectives; hands-on learning activities in math, science, and technology; readings; and assessment activities. IMaST modules are available from Glencoe/McGraw-Hill. (Center for Mathematics, Science, and Technology, 2002) For more information on the World Wide Web, go to http://www.ilstu.edu/depts/cemast/imast/imasthome.htm.

The **Technology, Science, Mathematics Connection Activities** is a collection of six detailed activities that integrate technology education, science, and mathematics in the middle school. These engineering-like activities challenge students to design, construct, and evaluate solutions to real-world problems of interest to them. The activities encourage technology, science, and mathematics teachers to work together as a team. Each activity includes detailed information for science, mathematics, and technology teachers. The *Technology, Science, Mathematics Connection Activities* are available from Glencoe/McGraw-Hill (LaPorte & Sanders, 1996). For more information on the World Wide Web, go to http://teched.vt.edu/TechEd/HTML/Research/TSMOverview1.html.

Science and Technology: Investigating Human Dimensions is a three-year activity-based program for students in grades 5–9. Students explore science and technology by doing investigations and reading about how science and technology relate to their lives. Student books and teacher guides accompany units on patterns of change, limits and diversity, and equilibrium. The program encourages the participation of female, minority, and disabled students, emphasizes reasoning and critical thinking, and illustrates careers. These materials are available from the Kendall/Hunt Publishing Company as the *Middle School Science and Technology* textbook series (BSCS, 1999). For more information on the World Wide Web, go to http://www.kendallhunt.com/elhi/.

FIRST Jr. Robotics (LEGO League) is a national competition sponsored by the FIRST™ organization, for students age 9–14. A challenge designed around a LEGO robotics kit is presented in the fall. Students have 10 weeks to research, design, and build a robot that can "solve" the challenge. Their solution may then be entered in a one-day local and (if successful) state tournament (FIRST, 2002a). For more information on the World Wide Web, go to http://www.usfirst.org/jrobtcs/flego.htm.

Craftsman/NSTA Young Inventors Awards Program is a national competition that includes a middle school division (see description in the section entitled Elementary-Level Approaches/Projects mentioned earlier).

Toshiba/NSTA ExploraVision Awards Program is a national competition that includes a middle school division (see description in the section entitled Elementary-Level Approaches/Projects mentioned earlier).

High School Level Projects

High schools present a unique set of challenges for interdisciplinary instruction. The goal of preparing students to meet college entrance requirements and perform well on standardized tests encourages high schools in the United States to teach conventional courses in conventional ways. Nevertheless, the increasing sophistication of the high school technology education curriculum—especially in the realm of digital technologies—and ubiquitous electronic communication capabilities provide new opportunities for interdisciplinary instructional approaches in high schools. The following resources provide a starting place for those embarking on interdisciplinary instruction at the high school level.

Science that Counts in the Workplace is a full-year physical science course for 11th- and 12th-grade students embedded in the context of workplaces/fields such as engineering, manufacturing, maintenance and repair, transportation, architecture, and construction. The course is targeted to students who have not thrived in conventional science courses. It is particularly appropriate for use in career academies and high schools organized by career clusters (Technology Education Research Center, 2002b). For more information on the World Wide Web, go to http://www.terc.edu/TEMPLATE/projects/item.cfm?ProjectID=30.

Science by Design is a series of four texts that integrate science and technology through design-and-build projects entitled *Construct-a-Boat, Construct-a-Greenhouse, Construct-a-Glove,* and *Construct-a-Catapult.* These units provide students with a hands-on approach to the physics of product design. They blend biology, physical science, physics, and earth science with technology education processes and topics. The materials focus on selected process skills: communicating, designing and building, testing, planning and conducting experiments, analyzing data, and modeling (Technology Education Research Center, 2002a). For more information on the World Wide Web, go to http://www.terc.edu/TEMPLATE/products/item.cfm?ProductID=3.

National Super-mileage Competition provides high school students an opportunity to engage in a rich, safe, and authentic research and development experience. This competition challenges students to design, construct, and enter a high-mileage vehicle competition hosted by the Minnesota Technology Education Association (MTEA). Some participants reach over 800 miles per gallon in the sleek vehicles they have designed and built. Three classes comprise the competition: (1) Stock—which uses a 3.5 hp Briggs and Stratton engine with no modifications; (2) Modified—which uses a 3.5 hp Briggs and Stratton modified engine where the base construction remains Briggs and Stratton; and (3) Concept—which uses any engine that burns gasoline (MTEA, 2002). For more information on the World Wide Web, go to http://www.mtea.net.

FIRST Robotics is a high school competition sponsored by FIRST™, a non-profit organization whose mission is to generate an interest in science and engineering among today's youth (the acronym stands for "For Inspiration and Recognition of Science and Technology"). In the FIRST Robotics competition, kids, teachers, and engineers work together in creating robotic devices with which they compete in local, state, and national tournaments (FIRST, 2002b). For more information on the World Wide Web, go to http://www.usfirst.org/robotics/index.html.

National Engineering Design Challenge (NEDC) is a high school program sponsored by the Junior Engineering Technical Society (JETS) in which teams of students design, build, and demonstrate a working solution to a societal need. NEDC challenges students to apply mathematics, science, and technology to a real-world engineering situation. Solutions developed should be usable by people with or without disabilities. Each team must work with an advising engineer who provides general information about engineering design principles and technical information about project specifics, verifies the safety of the project, teaches the team research methods, and serves as a resource link between the team and the community (Junior Engineering Technical Society, 2002). For more information on the World Wide Web, go to http://www. engineeringnet.org/nedc.htm.

Winston Solar Challenge is designed to teach high school students the physics and technology associated with a roadworthy solar car. Its objective is to encourage student interest in science, engineering, and solar technology. Emphasis is placed on the sharing of knowledge and the development of new friendships rather than on the intensity of competition. The major components of the vehicle must be designed and constructed completely by the students, though they may seek the advice of engineers or other design consultants. In even-numbered years, the competition is a three-day closed-track race at the Texas Motor Speedway. In odd-numbered years, it is a three-day cross-country race (Winston Solar Challenge, 2002). For more information on the World Wide Web, go to http://www.winstonsolar.org/dhtml/.

Toshiba/NSTA ExploraVision Awards Program is a national competition that includes a high school division (see description in the section entitled Elementary-Level Approaches/Projects mentioned earlier).

SUMMARY

Many compelling reasons encourage those developing technological studies curricula to consider interdisciplinary instructional strategies. Were it not for the fact that school subject matter has been "compartmentalized" throughout the last century, an interdisciplinary instructional approach to the study of technology might already be commonplace. Technology is not a "stand-alone" entity but rather is intertwined with nearly every aspect of our lives. Thus, an interdisciplinary approach to the study of technology is more logical than a segregated approach.

The "technological problem-solving" method, in which students are challenged to design, construct, and evaluate solutions to problems, has been embraced not only by technology education, but by innovative science teachers, social studies teachers, and elementary educators as well. Many National Science Foundation projects, arguably among the most innovative of all science educational materials, are grounded in the "technological problem-solving" method.

Research from a variety of disciplines suggests "chunking" abstract facts with practical experience—a common byproduct of the "technological problem-solving" method—is sound pedagogy. Not surprisingly, the sourcebooks for educational reform in America of the last two decades and many of the national standards that followed—particularly the science, social studies, and technology education standards—call for the implementation of interdisciplinary instructional strategies to technology education.

Just recently, the National Academy of Engineering (NAE) and National Research Council (NRC)—which enjoy considerable political clout—released a book titled *Technically Speaking: Why Every American Should Know More About Technology* (Pearson & Young, 2002). *Technically Speaking* is the report of two years of study by the Committee on Technological Literacy established by the National Academy of Engineering. This book—more than any that preceded it—promotes an interdisciplinary approach to the study of technology as the preferred means for achieving technological literacy in America. Specifically, their recommendations include the following:

Recommendation 1. Federal and state agencies that help set education policy should encourage the integration of technology content into K–12 standards, curricula, instructional materials, and student assessments in non-technology subject areas.

Recommendation 2. The states should better align their K–12 standards, curriculum frameworks, and student assessment in the sciences, mathematics, history, social studies, civics, the arts, and language arts with national educational standards that stress the connections between these subjects and technology. The National Science Foundation (NSF) and Department of Education (DoEd)-funded instructional materials and informal-education initiatives should also stress these connections.

For those wishing to pursue an interdisciplinary instructional approach to technology education, good news awaits. The education reform efforts of the last two decades, the national standards documents of the 1990s, and the politics of the 21st century support this approach to the study of technology. Moreover, a wealth of existing curriculum material is available to those embarking on the journey. And, while interdisciplinary technology education remains the exception rather than the rule, a growing body of anecdotal evidence points to the benefits derived when the study of technology cuts across traditional boundaries in education.

DISCUSSION QUESTIONS

1. Why is the concept of interdisciplinary instruction so important to consider in the technology education classroom?
2. What are some of the challenges to overcome as technology education teachers begin to incorporate interdisciplinary instructional strategies in the classroom?
3. Which of the interdisciplinary instructional approaches from Fogarty's and Jacob's work seem most appropriate for your philosophy of technology education?
4. Why has it taken so long to incorporate interdisciplinary instructional strategies into our educational system?

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Teaching Social/Cultural Impacts in Technology Education

Chapter 6

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INTRODUCTION

We are at a defining moment in the history of technology education. The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) have been released with the backing of the International Technology Education Association, the National Aeronautics and Space Association (NASA), and the National Science Foundation (NSF). It is important to note that four out of the twenty content standards specifically address technology and society. That is why the content of this chapter is so timely. Now that the foundation has been set, it is time to implement curricular and instructional design changes that reflect the needs of a changing society.

PURPOSE

The purpose of this chapter is to provide information on how social and cultural impacts can be effectively addressed when teaching technology. This chapter will be a valuable resource for classroom teachers when modifying their curriculum to address the content standards that relate to social and cultural impacts. University technology teacher educators will find this chapter useful when preparing future teachers by providing them with instructional strategies that address social and cultural impacts. Graduate students will also find this chapter to be beneficial as a resource whether they are preparing to become master teachers, developing standards-based curriculum, or exploring a professional research agenda.

SOCIAL/CULTURAL IMPACTS

Technology, society, and culture are all common terms. But one only needs to consider the word *technology* to understand that terms often mean different things to different people. Consider the variety of interpretations of the word *technology.* According to an ITEA/Gallup poll on technological literacy (Rose & Dugger, 2002), two-thirds of the American respondents "think only of computers and matters related to the Internet" (p. 1) when they hear the word *technology.* It is no surprise that most technology committees in school districts focus on policies related only to computers. The meanings of words also evolve over time: "As the definition of technology changed, its meaning became more vague, leaving room for misconceptions" (Pearson & Young, 2002, p. 51). Because of the evolutionary nature of language and since the thrust of this chapter requires an understanding of the relationship among technology, society, and culture, it is important to first clarify these terms.

Definitions

Technology

A plethora of definitions of technology are cited in the literature. Rather than to rehash that which has already been over-analyzed, the following definition is offered from the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000):

> Broadly speaking, technology is how people modify the natural world to suit their own purposes. From the Greek word *techne,* meaning art or artifice or craft, *technology* literally means the act of making or crafting, but more generally it refers to the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants. (p. 2)

Society

A society is any group of people who freely associate with each other for the purpose of some common goal. Dewey (1915) defined *society* "[as] a number of people held together because they are working along common lines, in a common spirit and with reference to common aims" (p. 14). This definition parallels the *Webster's New Collegiate Dictionary* (1981) second entry for society: "a voluntary association of individuals for common ends; esp.: an organized group working together or periodically meeting because of common interests, beliefs, or profession" (p. 1094). It is interesting to note that while, by definition, a society must be larger than one person, none of these definitions puts a limitation on the size of the group. A society could include a small social club of two or involve millions of people such as the members of the Inca Empire.

Textbook definitions tend to include additional variables when defining society. Nanda and Warms (1998) in their cultural anthropology text suggest "society is a group of people who depend on one another for survival and well-being" (p. 3). According to this definition, a group organized and structured around family bloodlines such as Scottish clans qualifies as a society. A society could also include Native American tribes whose members share hunting and other survival responsibilities.

Macionis (2001) offers this typical sociology textbook definition: "People who interact in a defined territory and share culture" (p. 89). Historically, geographic location was an important determiner when defining the characteristics of a society, but today, modern transportation and electronic communication technologies have altered the importance of including the concept of a limited territory as part of a defining element of a society. On the other hand, the concept of a shared culture is as important today as it was 1000 years ago.

Culture

Any time a group congregates as a society, members of that group tend to develop their own habits, behaviors, and ways of being. *Culture* can be defined as "the integrated pattern of human behavior that includes thought, speech, action, and artifacts and depends upon [humans'] capacity for learning and transmitting knowledge to succeeding generations" (*Webster's New Collegiate Dictionary,* 1981, p. 274). According to Pytlik, Lauda, and Johnson (1985), three common factors pervade definitions given by sociologists and anthropologists. The first common factor is that culture is learned, not inherited genetically. Using this tenet as a guide, language would be considered a cultural phenomenon whereas physical characteristics such as skin pigmentation would not. The second common factor identified by Pytlik, Lauda, and Johnson (1985) is that culture is modified as it is passed on from generation to generation. Because the way people communicate continues to evolve over time, language evolves as new slang becomes common and eventually becomes adopted as part of the mainstream. The third common factor that pervades definitions of culture is the way in which humans assign meaning to their lives. This assigning of meaning is often done through the meaningful alteration of their environment. Values and symbolism are given to the materials with which they come in contact and the artifacts that are created, exemplified by the status attributed to the clothing and the meaning some give to how it is worn.

Macionis (2001) defined *culture* as "the values, beliefs, behaviors, and material objects, that together form a way of life" (p. 61). He also made distinctions between nonmaterial and material culture. *Nonmaterial culture* is defined as "the intangible world of ideas created by members of a society, ideas that range from altruism to Zen" (Macionis, 2001, p. 61). *Material culture* is defined as "the tangible things created by members of a society" (Macionis, 2001, p. 61). The ways in which different societies design and create technologies, their material culture, provide insight to their values and beliefs, their nonmaterial culture.

INTERRELATIONSHIPS BETWEEN TECHNOLOGY, SOCIETY, AND CULTURE

The world is filled with physical evidence of how humans have altered their environment. Much of what we proclaim to know about past societies is based on the artifacts that archeologists have found. If it were not for the discovery of tools, clothing, and remnants of structures, our understanding of prehistoric cultures would be greatly limited. To understand the technology of a culture is to provide a deeper understanding of the creators of that technology. Ever since the first technologies were invented, a symbiotic relationship was established. Technologies exist because of the ingenuity of humans. And human lives have been altered because of their creations. If technology is changed or altered, then society is generally affected. For this reason, technology must also be studied from a social and cultural viewpoint. If the study of technology is limited to the manipulation of materials or the creation of artifacts, without further attention to understanding the social and cultural contexts which govern its creation and implementation, then the goal of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) will not be met.

One of the defining features of a society is the culture established when a group adopts its own protocols or alters its physical environment. Rules of thumb evolve, ways of living are propagated, and rituals are established. Societies create technologies that reflect their culture, as well, just as a culture limits the technologies that are created and/or implemented. In addition, groups, regardless of their size, can establish ways of communicating that prohibit outsiders from functioning effectively within the group. When someone is disoriented because of an experience with an unfamiliar way of life, it is called culture shock (Macionis, 2001). Sometimes this disorientation is intentional, while at other times, social change may occur leaving those who are not early adapters to muddle along behind the learning curve. Mesthene (2000) suggested that technology-driven social change could be explained as a four-step process:

> The usual sequence is that (1) technological advance creates a new opportunity to achieve some desired goal; (2) this requires (except in trivial cases) alterations in social organization if advantage is to be taken of the new opportunity; (3) which means that the functions of the existing social structures will be interfered with; (4) with the result that other goals which were served by the older structures are now only inadequately achieved. (p. 63)

An example of this sequence is the invention of the automobile. The automobile provided a new opportunity for travel. In order for the automobile to be successfully adopted, the social structure that governed the transportation infrastructure in our country had to be altered. A need was created for places to purchase fuel and service automobiles. At the same time, the demand for harness makers and other occupations related to transportation systems that relied on animal power diminished. As a result, some of the occupations related to the use of animals for transportation still exist, but clearly not at the level they did 100 years ago.

One mistake commonly made when examining impacts as they relate to technology, society, and culture is to look only at how technology impinges on society. However, it is equally important to note that the culture of a society often can impact the invention and implementation of technology. Using the automobile once again as an example, one needs to look only as far as the Amish to understand this point. The Amish have an established culture that shuns the invention of the automobile. They know that the technology exists but have refused to make it a part of their everyday lives because of their own values and beliefs.

TEACHING SOCIAL/CULTURAL IMPACTS IN THE TECHNOLOGY EDUCATION CLASSROOM

Teachers can choose various approaches to teaching the relationships among technology, society, and culture. The approaches can be organized along a continuum based on the scale ranging from integrated content to topical lessons, from unit activities to complete courses.

One approach is to integrate technology and society content throughout the existing curriculum. For example, exploring current issues related to regional trends could enhance a manufacturing lesson. Questions could be posed that ask students to explore the impacts a manufacturing facility has on the people in its local community. How many people are employed in the plant? How many are employed in jobs that provide materials and services for the plant? Similar types of topics could be developed and integrated across the technology curriculum.

Another approach is to develop standalone topical lessons that specifically address technology and society issues. For example, a communications technology lesson could be developed that asks students to explore the concept of privacy in the age of the Internet. Students could contemplate how humans have benefited and have been harmed by a technological system that was created to increase a human's ability to exchange information. Such technology and society related lessons could be added to enhance pre-existing units.

The unit activity is another valuable way to incorporate social and cultural content. The unit could be developed not as an enhancement to a pre-existing lesson but as a standalone topic/activity that specifically addresses technology and society content. The unit could include a series of related lessons and activities organized around a central theme. One approach is to have students interview grandparents or senior citizens about what they perceive to be the most influential technology they have encountered in their personal lives. This activity would start with a preinterview to identify the technology to be investigated. Next, students would research the historical development of the technology selected. They could also either develop a physical model of the technology or simulate its operation. Students could also be asked to develop a list of interview questions based on their research on the history of the technology, along with the development of a video of the interview. The final product could be a multimedia presentation stored on a CD or Web page that documents each aspect of the project. It would include links to a research paper about the historical development of the technology, pictures of the technology and the interviewee, a biographical sketch of the interviewee, digital video of a memorable moment from the interview, and a complete transcript of the interview including the questions and responses. Such an activity would provide students with an in-depth understanding of how technology can impact society through the personal experiences of an individual.

The most ambitious approach is to create a separate course dedicated to the coverage of the relationship among technology, society, and culture.

Suggested topics might include but definitely would not be limited to the following:

A) Studying interrelationships among technology, society, and culture
   1) Technology and social change
   2) Technology and culture
B) Attempting to assess and control technology
   1) Technological politics
   2) Technology assessment
   3) Cost/benefit analysis
   4) Risk assessment
   5) Futuring
C) Confronting technological issues
   1) Privacy in the age of the Internet
   2) Technology used to create, prolong, and/or end life
   3) Cloning and genetic engineering
   4) Improved technology and its relationship to progress
D) Noting trends
   1) Nanotechnology
   2) Macrotechnology
   3) Genetic engineering

Creating a class provides students with opportunities to explore the relationship among technology, society, and culture at a very deep, rich level. The state of Wisconsin has recently endorsed a similar type of class at the high school level as an advanced placement course that can be used for university credit. Although a class like this may provide an opportunity for college-bound students to earn college-level credits, the content is appropriate for all students.

STRATEGIES FOR TEACHING SOCIAL/CULTURAL IMPACTS

A Case for Case Studies

One method of incorporating content that addresses the interrelationship among technology, society, and culture is to utilize case studies. Case studies have been used very effectively in medical and law schools. Because students have limited experiences, case studies provide an opportunity to investigate real world events that they may not otherwise have experienced. One approach is to investigate historical events. For example, much has already been documented about catastrophes such as the Hindenburg, the Titanic, the Challenger, Three-mile Island, Chernobyl, and the attack on the World Trade Center in New York City. Pre-existing accounts of these events allow students to investigate how society changed in reaction to such catastrophes. Another approach is to have students write their own case studies. They can do observations and interviews to gather information to document how technology has impacted a person, a group of people, a company or business, or the natural environment. Students could also write personal case studies. They could document how they have been impacted by a technological innovation. Another interesting approach is to combine the idea of futuring with the case study approach. Students could write predictive case studies explaining how life might be different for individuals in the future because of technological inventions and innovations. Case studies provide students with a variety of opportunities to investigate the relationships between technology and society.

RELATIONSHIP TO STANDARDS FOR TECHNOLOGICAL LITERACY

Chapter 4 of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000), titled "Technology and Society," outlines four standards, standards 4–7, that relate specifically to the content of this chapter of the yearbook. Because standards represent big ideas, no single approach will be sufficient to address these standards. It is recommended that a combination of approaches be utilized to give students multiple exposures to key ideas and concepts over time in order to meet the rich intent of the standards. These are the Technology and Society Standards:

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

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

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

Standard 7: Students will develop an understanding of the influence of technology on history. (ITEA, 2000, p. 210)

ACTIVITIES

Activities that illuminate the relationship among technology, culture, and society can be implemented at all grade levels. The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) include benchmarks at various age levels for each standard. The following are example activities that could be implemented to address selected benchmarks. Each suggested activity starts with the listing of the targeted standard and specific benchmark(s).

Grades K–2 Activity

Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology (ITEA, 2000, p. 57).
Benchmark A: The use of tools and machines can be helpful or harmful (ITEA, 2000, p. 58).

At the early elementary level, students could be asked to bring in pictures of common technological artifacts. They should be encouraged to bring in a variety of examples that cut across human endeavors. As a class they could pick one and describe for what purpose it was created: How did its inventor intend for it to be used? They could also brainstorm other applications of the technology for which it could be used beyond its intended purpose. Asking how that particular technology could be used to help people and how it could be used to harm people could help students understand that technology can be both harmful and helpful.

Grades 3–5 Activity

Standard 6: Students will develop an understanding of the role of society in the development and use of technology (ITEA, 2000, p. 73).
Benchmark C: Individual, family, community, and economic concerns may expand or limit the development of technologies (ITEA, 2000, p. 76).

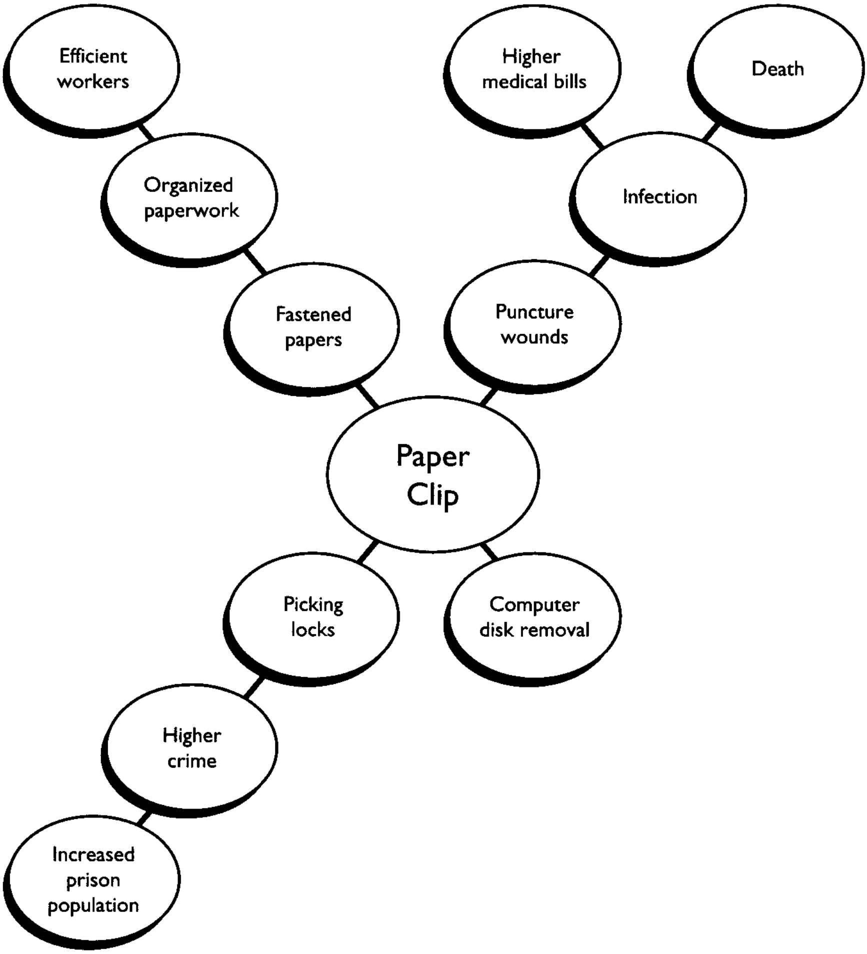
Elementary-aged students can learn much through interactions with other students their age from other parts of the country or world. The idea of using pen-pals to share information is not new, but the ability to do so has been enhanced with the introduction of the Internet. A classroom teacher could establish connections with teachers from other parts of the country or world to help organize a pen-pal activity where students are given an opportunity to learn first hand that technology can vary from region to region or country to country. This activity will work best if caution is taken to identify schools from diverse areas. Students from a seaport in Maine, a mining town in West Virginia, a ranching community in western Kansas, and an urban school in New York City could provide a variety of different responses to the same questions. Students from different countries would provide an even greater variety of responses. Possible questions to be explored could include the following: How do you get to school? How many televisions do you have? Where do your parents work? What kind of house do you live in? Students could also be encouraged to send digital pictures showing examples of local transportation, construction, architecture, communication systems, etc. A pen-pal activity such as this could help students understand that technology can be similar but can also vary from family to family, community to community, state to state, and country to country.

Grades 6–8 Activity

Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology (ITEA, 2000, p. 57).
Benchmark C: The use of technology can have unintended consequences (ITEA, 2000, p. 59).
Benchmark D: The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use (ITEA, 2000, p. 60).
Benchmark E: Technology by itself is neither good nor bad, but decisions about the use of products or systems can result in desirable or undesirable consequences (ITEA, 2000, p. 60).

An appropriate middle school activity that would help meet these benchmarks could involve the exploration of the impacts of an existing technology. One method to explore possible impacts is to have students create a web diagram placing the technology to be investigated in the middle. Simple technologies like a paper clip often work as well as complex technologies. Next, have the students list the primary impacts of the technology in circles surrounding the technology with lines linking them back to it. See **Figure 6-1. Impacts of Technology.** Then, students should list the secondary impacts with lines linking them back to the related primary impacts of the technology. Last, have students list tertiary, or third-level impacts, making connections back to the related secondary impacts. Once students have explored levels of impacts, they should be asked to categorize each impact into the following categories: intended/desirable, unintended/desirable, intended/undesirable, unintended/undesirable. Students could explore impacts of the same technology individually, and the instructor could instruct them to compare their results with each other using cooperative learning techniques.

Figure 6-1. Impacts of Technology.



Grades 9–12 Activity

Standard 5: Students will develop an understanding of the effects of technology on the environment (ITEA, 2000, p. 65).

Benchmark H: When new technologies are developed to reduce the use of resources, considerations of tradeoffs are important (ITEA, 2000, p. 71).

Benchmark J: The alignment of technological processes with natural process maximizes performance and reduces negative impacts on the environment (ITEA, 2000, p. 72).

Benchmark K: Humans devise technologies to reduce the negative consequences of other technologies (ITEA, 2000, p. 72).

Benchmark L: Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment (ITEA, 2000, p. 72).

Many technology education programs have incorporated design and problem-solving activities. Researching possible positive and negative impacts of a design solution can easily become a standard part of any evaluation criteria that is used when selecting the optimum solution. The perfect place to begin is to require that social/cultural impacts be incorporated into design specifications. Design specifications should not only include desirable functional qualities but also should focus on impacts on the environment and society. Typical criteria could focus around questions such as these: What percent of the materials used in the design solution can be recycled? Does the design solution require electricity? Does the design solution require materials that require an exorbitant amount of primary processing that has adverse consequences for the environment? Students could also be asked to determine whether any social/cultural barriers might inhibit the implementation of their design solution including a list of possible policies or regulations that would need to be developed if the new technology were to be successfully implemented. Asking students to incorporate these types of questions in their analysis of possible solutions will help them understand that selecting optimal design solutions involves tradeoffs.

SUMMARY

Technology education has evolved with a rich tradition. It is interesting to note that many prominent philosophers in education have called for better linkages between schools and society. Dewey (1915) started calling for the reformation of schools to better reflect the social changes that were occurring in the United States approximately 100 years ago. Leaders in our field, such as Don Maley, introduced curriculum that included technology and society content 50 years ago. Now, with the publication of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) to guide the content for the study of technology, we have some clear goals for technology education across the nation. Human beings continue to mold and shape their worlds through the use of technology, and in turn technology has changed many lives. It is only fitting that students gain a better understanding of interrelationships between the human-altered world and the cultures and societies that molded them. In what better place should this occur than in our schools as a part of every child's formal education.

DISCUSSION QUESTIONS

1. Why is it important for technology education teachers at all levels to incorporate the social and cultural impacts of technology?
2. What are the differences between the words *society* and *culture* when speaking of technology?
3. What is the difference between material and nonmaterial culture?
4. Can you provide an example of the four-step process Mesthene used to describe technology-driven social change?
5. Can you develop a case study of how technology, society, and culture interrelate?
6. Can you develop an outline for a complete course of study that shows the integration of technology, society, and culture?

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Design and Problem Solving in Technology Education

Chapter 7

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INTRODUCTION

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

- A high capacity for abstract, conceptual thinking;
- The ability to apply that capacity for abstract thought to complex real-world problems—including problems that involve the use of scientific and technical knowledge—that are nonstandard, full of ambiguities, and have more than one right answer—as jobs change in response to a constantly changing market and the opportunities provided by advancing technology;
- The capacity to function effectively in an environment in which communications skills are vital—in work groups, through the use of computer-based systems that require real mastery of written English, and by reading technical manuals that necessarily presume a high degree of both reading ability and technical competence;
- The ability to work easily and well with others, and the skill required to resolve conflicts that arise with colleagues and assume responsibility for the work that needs to be done without requiring much supervision (p. 81).

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

PURPOSE

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

DEFINITION OF DESIGN AND PROBLEM-SOLVING

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

COMPONENTS OF THE INSTRUCTIONAL STRATEGY

Design and Problem-solving

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

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

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

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

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

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

Many models for the process of design can be considered, ranging from some models containing 30 steps to those containing only four. One model having a great deal of acceptance has been developed by Pahl and Beitz (1996), which defined four steps in the design process:

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

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

The second aspect of design is the conceptual design process. Imbedded in this stage is a process called ideation, or, the formal conceptualizing of design ideas. The ideation process is formal and should require students to submit a written procedure of the exact process used for the specific design they are working toward. A multitude of processes can be used for ideation, such as a knowledge box, a morphological matrix, or analysis of existing systems. Any design text will have a variety of ideation techniques. **Figures 7-1. Knowledge Box** and **7-2. Morphological Matrix of Simple Transportation Design** show ideation processes commonly used for conceptual design.

Figure 7-1. Knowledge Box is called a knowledge box, used to graphically combine "knowns and unknowns" of a potential conceptual design. Knowledge boxes are easy for students to understand and have the advantage of graphically illustrating potential tasks related to the necessary processes for finalizing a conceptual design. For example, if a large number of items are listed as "know you don't know," this would demonstrate a need for research into these areas. The typical characteristic of a knowledge box is that initially the top row has most of the information and the bottom row gets filled in as time progresses.

7-2. Morphological Matrix of Simple Transportation Design is a process is used to rapidly distinguish between viable approaches and designs with a low chance of success. The different axes of the matrix represent the initial components of a conceptual design. Morphological matrices lend themselves to systems designs, requiring the interaction of different parts in a design. Systems designs are extremely common in technology. These matrices allow different parts of the system to be rapidly compared for compatibility. The advantage of this type of comparison is that it helps to prevent the creation of design concepts that are created in isolation, by comparing them as interactive parts in a larger system.

Figure 7-1. Knowledge Box.

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

Figure 7-2. Morphological Matrix of Simple Transportation Design.

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

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

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

Development of Production Capabilities

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

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

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

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

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

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

Influences on Design and Problem-solving

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

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

APPLICATION OF DESIGN AND PROBLEM-SOLVING

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

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

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

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

RELATIONSHIP TO STANDARDS FOR TECHNOLOGICAL LITERACY

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

Middle School Design and Problem Solving

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

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

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

High School Design and Problem Solving

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

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

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

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

Undergraduate Design and Problem Solving

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

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

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

SUMMARY

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

DISCUSSION QUESTIONS

1. Why is it important to include design and problem solving instructional strategies in the technology classroom?
2. Which is more important for students, the design process or the final product being designed, and why?
3. Why is it important in the design process to include not only the technological solution, but also the requirement that the solution must fit into society?
4. What are the important characteristics of an accepted design process and why are they important?

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Inquiry in Technology Education

Chapter 8

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INTRODUCTION

Technology education involves much more than instruction of the artifacts and methods of technology. The increasing amount and complexity of technology require students to know *how* to use, manage, assess, and understand technology. Inquiry is a cognitive instructional strategy that can help students learn about current technologies and also provide them with tools for investigating emerging technologies as they are encountered.

PURPOSE

The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) outlines an interdisciplinary approach for teaching technology as discussed in Chapter 5. As part of that interdisciplinary approach, inquiry is an ideal instructional strategy for implementing the *Standards* because it is based on a problem-solving model. Indeed, an unlimited number of learning possibilities can be created for individual students or for groups of various size through the use of inquiry. The use of inquiry instructional strategies allows for student- or teacher-directed technology activities, which can be conducted solely in the technology laboratory or integrated between or among subject areas.

This chapter defines *inquiry* as the formal process instructional planners call inquiry-training. *Inquiry-training* is a cognitive method for students to investigate their curiosities in a disciplined manner that is similar to the scientific method.

INQUIRY-TRAINING

The inquiry-training model developed by J. Richard Suchman in 1962 is the foundation for inquiry instructional strategies. Suchman created the inquiry-training model to provide a formal investigative process for the classroom. The model is based on the premise that children are naturally curious when confronted with unknown phenomena. The goal of the inquiry-training model is to teach students how to take this curiosity and focus it in a structured way using questioning and hypothesis testing. An important social component of the process is to have students present their results. The key to perpetuating the process is to have students evaluate their inquiry session to learn what works and what needs improvement. This reflection raises further student curiosities and creates new directions for learning. In Suchman's (1962) own words, inquiry-training was created to:

> Develop the cognitive skills of searching and data processing, and the concepts of logic and causality that would enable the individual child to inquire autonomously and productively; to give the children a new approach to learning by which they could build concepts through the analysis of concrete episodes and the discovery of relationships between variables; and to capitalize on two intrinsic sources of motivation, the rewarding experience of discovery and the excitement inherent in autonomous searching and data processing. (p. 28)

Suchman based the model on his own observations and the work of Jerome Bruner, Jean Piaget, and John Dewey. Bruner found that people tended to develop new ideas by linking to successful patterns of knowledge from their past. This was consistent with Suchman's observations that individuals were able to develop a style of thinking that could be used in a wide range of applications. Piaget's concept of operational thinking claimed that children went through progressive stages in the way they think. From this research, Suchman speculated that formal stages of inquiry could be developed and taught to all children. This part of the model was also based on Dewey's premise that the scientific method should be introduced to all school children (Suchman, 1962).

Inquiry-training has proven successful in various grade levels and subject areas, as well as with special needs students. In the 1960s and 1970s, inquiry-training was used by science and social studies teachers to increase interest and activity in the classroom (Weaver, 1985). Voss (1982) found that inquiry-training was effective at both the elementary and secondary levels. A third study successfully used the inquiry process with deaf children (Elefant, 1980). These studies, along with Suchman's own observations, highlight the effectiveness of inquiry-training as a cognitive tool. Following are some of the student-learning outcomes when using the inquiry instructional strategy:

1. Students acquire process skills of observing, collecting, and organizing data; identifying and controlling variables; formulating and testing hypotheses and explanations.
2. Students develop independent learning techniques that involve asking questions, testing ideas, and making decisions.
3. Students enhance their ability to express themselves verbally by asking questions. Likewise, their listening and comprehension ability improves from receiving answers and synthesizing the replies.
4. Students acquire persistence through data gathering and experimenting to solve the problem situation.
5. Students develop logical thinking skills through following an organized method of inquiry.
6. Students learn a strategy by which new knowledge can be obtained (Daiber, 1988, p. 168).

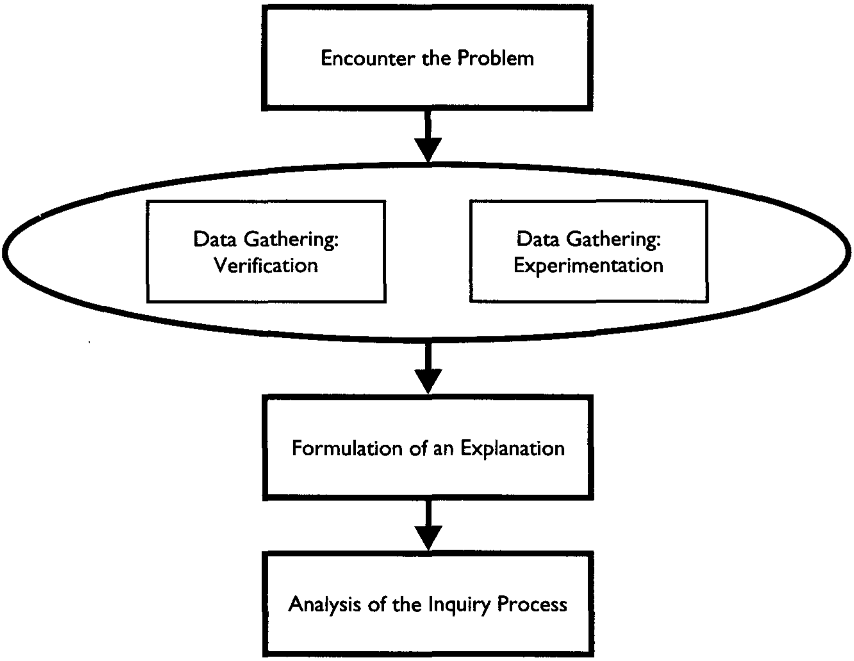
Phases of the Inquiry-training Process

Initially, Suchman (1962) included four types of student action within the inquiry-training model: searching for information, data processing, discovery, and verification. Although these four steps were not new cognitive concepts, putting them together in a model was unique. When used together in the inquiry process, they form a cycle of operation that can be learned and used in various technology learning situations. The evolution of inquiry-training has established a model with five phases (Joyce, Weil, & Calhoun, 2000). It is important to note in **Figure 8-1. The Inquiry-Training Model** that the inquiry process is not entirely linear. The data gathering phases, verification and experimentation, often occur simultaneously.

Encountering the Problem

The first phase of the inquiry process occurs when the teacher presents the students with a problem. Beginning problems will be simple until students understand the inquiry process. However, care should be taken to present a problem that is sufficiently challenging. Objectives and background information, as well as demonstrations, are presented at this time. The structure of the inquiry process should also be reviewed, especially acceptable questioning, data gathering techniques, and respect for other students.

Figure 8-1. The Inquiry-Training Model.



Gathering Data—Verification

During this phase, students learn the nature of the problem situation. This usually involves an exchange of questions between the class and teacher. Students should be reminded to ask only simple "yes" or "no" questions. If a question requires an elaborate answer, the instructor usually asks the student to rephrase the question. This form of questioning allows students to gather enough data to verify the problem but not enough to form premature conclusions that may be inaccurate.

Gathering Data—Experimentation

The third phase often runs concurrent with the second. At this point, students are ready to isolate variables and run tests to verify or refute questions they formulated in the verification phase. Hypotheses are now formulated based on the results of experimentation.

Experiments can be either exploratory or direct testing. Explorations are used to see what will happen to a variable and are often conducted without the guidance of a hypothesis. These can be thought of as sub-tests that will help establish theories. Direct testing is associated more closely to the overall problem and directly tests hypotheses (Joyce, Weil, & Calhoun, 2000).

Formulating an Explanation

This phase in the inquiry process requires students to formulate a conclusion and present their results. Students at this point should understand that many technological problems can have multiple solutions. Some inquiry sessions might even result in non-technological conclusions. Teachers can use this step in the process to discuss the impacts of technology and to allow for student discussion. Creativity and higher-level thinking is often fostered by allowing students to use a wide variety of presentation techniques and tools. Time should be spent reviewing how to analyze, synthesize, and evaluate the new knowledge.

Analyzing the Inquiry Process

The final phase requires students to evaluate the inquiry process that just occurred. Students should look for questions and experiments that were effective, as well as for ways to improve the process. The teacher can review teamwork skills, observe behaviors, and even re-create experiments. Joyce, Weil, and Calhoun (2000) suggested the use of repetition to reinforce the process and to review the cognitive and social benefits of the model.

Analysis of the inquiry process is unique and vital to the success of inquiry-training. Other problem-solving models often end at the presentation process, thus omitting lesson opportunities and important socialization skills. Reflection helps foster student curiosity for future inquiry. Analysis of the process also helps students learn their strengths and weaknesses while helping them become aware of the importance of life-long learning.

Role of the Teacher

The teacher's role during an inquiry-training session is much more complex than that of a facilitator guiding student interest. The instructor must know the subject matter, each student's strengths and weaknesses, as well as each student's varying progress throughout the inquiry session. Suchman (1966) outlined the following five duties that the teacher must focus on during the inquiry-training:

1. **Stimulate and challenge the students to think.** Situations should be designed to raise student curiosity and cause them to take action. If

the problem can be readily answered or found in a text, it does not cause the student to look outside of their existing body of knowledge. It is important for the teacher to let students know that complacency is unacceptable. The instructor must maintain an awareness of student efforts and remediate when necessary to bring back student interest. Suchman (1996) stressed the importance for students to be aware that the human body of knowledge is always changing. Existing knowledge changes not only from new discovery but also from social and cultural influences. An important goal for the inquiry-training teacher is to incorporate lessons based upon the *Standards* that explain the interaction between social and cultural factors and technology.

2. **Ensure freedom of operation.** Since inquiry-training is a cognitive process, a primary goal is to build student autonomy. The students should not feel pressure to achieve or have a fear of failure. This component not only builds student confidence but also helps build respect for differing views. To nurture these concepts, the teacher should take time to review techniques for working in groups. Professional communication, respect for others, and listening skills are all important to help students develop self-confidence.
3. **Provide support for inquiry.** Teachers need to guide student inquiry so that answers are discovered, not given. Since data collection and questioning guide the inquiry process, the teacher needs to provide avenues for gathering data and furthering the questioning process. Many materials and situations can be anticipated since the inquiry process begins as a teacher-directed experience. When the students move into the data gathering phases, however, the instructor will need to be flexible in order to support the students. At this point, the activity shifts from being a teacher-directed to a more student-directed activity.
4. **Diagnose difficulties and help the students overcome them.** The teacher must have an understanding of student strengths and weaknesses in order to help on an individual basis. Differences in personality, analytical ability, and the method in which a student handles new information are crucial to the success of the inquiry model. If the teacher is not an effective diagnostician, the student will lose confidence and direction.

5. **Identify and use the "teachable moments."** The effective teacher knows when new content can be introduced most effectively. The loss of student motivation is the risk of introducing a concept too early. Teachers flirt with student confusion and frustration if they let a teachable opportunity go by. Data provided at the right time, however, will keep student interest focused.

INQUIRY-TRAINING IN THE TECHNOLOGY EDUCATION CLASSROOM

Technology education has historically incorporated inquiry into laboratory instruction. Early forms of this instructional strategy, however, focused more on tools, materials, and technical processes (e.g., Earl, 1960, and Olson, 1963) rather than a structured cognitive process. The *Maryland Plan: Industrial Arts Program for the Junior High* (Maley, 1970) was one of the earliest programs that utilized an inquiry instructional approach in order to focus on the cognitive benefits of technology education. These cognitive benefits were first discovered by Maley in 1952 and were synthesized in *Research and Experimentation in Technology Education* (Maley, 1986) after decades of classroom testing and revision.

The research and experimentation program was viewed by Maley as an important method for aligning technology education with accepted educational concepts. Specifically, Maley (1986) felt that education must

- be fitted to the unique needs and interests of the individual,
- reflect the culture in which it functions,
- take advantage of the natural curiosity of youth,
- cause the learner to examine the "why" of things rather than the memorization of isolated facts,
- have its roots in the psychological needs of youth,
- encourage thought and inquiry,
- take into account the developmental tasks of youth,
- be meaningful to the learner,
- be interdisciplinary in its approach to the study of any topic,
- teach people how to learn (pp. 1–2).

A key component in *Research and Experimentation in Technology Education* (Maley, 1986) was the use of student seminars. Although students presented and discussed their research projects, analysis of the project, as outlined in the inquiry-training process early in this chapter, did not take place.

Daiber (1988) highlighted a second delivery system, the project method, that could effectively incorporate inquiry-training: "By using inquiry-training as the basis upon which the project idea is discovered, designed and constructed, the project becomes technological in nature" (Daiber, 1988, p. 166). The use of inquiry-training described by Daiber makes it ideal for both doing and learning about technology. Because doing and learning about technology are key concepts in the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) the inquiry-training model is an excellent teaching strategy for incorporating the *Standards* at any level.

USING INQUIRY-TRAINING, WITH THE STANDARDS FOR TECHNOLOGICAL LITERACY

The *Standards for Technological Literacy: Content for the Study of Technology* defines technological literacy as "the ability to use, manage, assess, and understand technology" (ITEA, 2000, p. 7). When used with the *Standards*, inquiry-training can help teachers accomplish these goals in several ways. First, students gain experience using technology during the data gathering phases. These opportunities provide an excellent occasion for invention and innovation since the inquiry process gives students a structure to help them analyze the technologies as they use them. Second, the inquiry model allows activities to be teacher or student controlled. The teacher can guide the use and management of technology based upon student ability level and resources. Third, inquiry-training is a cognitive strategy that allows students to consciously inquire, analyze, and improve their thinking (Joyce, Weil, & Calhoun, 2000). Thus, the use of the inquiry-training process can give students a tool to systematically assess and understand current and emerging technologies.

Sample Inquiry-training Activity for Middle School

The following lesson is designed to help the middle school teacher incorporate inquiry-training and the *Standards for Technological Literacy: Content for the Study of Technology.* This lesson starts with the corresponding standard and level-appropriate benchmark. Next, student performance standards highlight the skills students will gain from the lesson. Finally, the five steps in the inquiry process outline the lesson.

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

Benchmark G: Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively (ITEA, 2000, p. 178).

Objectives:

1. Students will explain the concept of an airfoil and Bernoulli's principle.
2. Students will conduct an experiment to compare different airfoil shapes.

Encountering the Problem. In the fall of 2000, a supersonic passenger plane crashed after a piece of debris punctured one of its tires on take-off. This accident illustrated how the swept (Delta) wing on a supersonic airplane does not provide much lift at slower speeds but helps it to achieve high speeds.

Data Gathering—Verification. The teacher should work with the students as a group to clarify terms and concepts associated with airfoils and Bernoulli's principle.

Data Gathering—Experimentation. Several experiments can be conducted to help students understand different wing designs and their applications on various aircraft. Students can work in small groups or individually to test different airfoils through computer simulation or through the construction and wind tunnel testing of airfoil designs.

Formulation of an Explanation. The instructor will need to guide student handling and presentation of data. Students at this level could be taught how to enter data into a spreadsheet and present their findings in table or chart form.

Analysis of the Inquiry Process. Students should look back at the questions and methods they used for their inquiry. Reflection allows the student to assimilate the new knowledge and form questions for a new inquiry. For example, to further address Benchmark G above, students could begin a new inquiry to explore the relationship between airfoils and aircraft control systems.

Sample Inquiry-training Activity for High School

The following lesson is designed to help high school teachers incorporate inquiry-training and the *Standards for Technological Literacy: Content for the Study of Technology.* This lesson again starts with the corresponding standard and level-appropriate benchmark. Next, student performance standards highlight the skills students will gain from the lesson. Finally, the five steps in the inquiry process outline the lesson.

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

Benchmark L: Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering (ITEA, 2000, p. 155).

Objectives:

1. Students will identify the positive and negative aspects of agricultural biotechnology.
2. Students will conduct an experiment to compare natural plants and plants altered through biotechnology.
3. Students should be able to explain the relationship between technology and individual preferences. The benefits biotechnology brings to one consumer, for example, might negatively affect another consumer.

Encountering the Problem. Biotechnology has been used in agriculture for thousands of years through the use of simple techniques such as animal husbandry, seed selection, and yeast for baking and fermentation. New processes that involve gene splicing and recombinant DNA, however, are controversial.

Data Gathering—Verification. The teacher should work with the students as a group to clarify terms and concepts associated with biotechnology.

Data Gathering—Experimentation. A simple experiment could have students compare the growth of genetically altered seeds to natural seeds. If vegetables are used, a taste-test could be used to gather consumer data. If time does not permit a laboratory experience, data could be obtained through student research. Each student could research a topic related to agricultural biotechnology and report their findings.

Formulation of an Explanation. The instructor will need to guide student handling and presentation of data. Students will need to be made aware that complex technologies often involve individual preferences. For example, biotechnology has created moral and ethical issues that have produced diverse philosophical and political opinions.

Analysis of the Inquiry Process. Students should look back at the questions and methods they used for their inquiry. Reflection allows the student to assimilate the new knowledge and form questions for a new inquiry. For example, to further address Benchmark L above, students could begin a new inquiry to investigate how the biotechnology on which they reported is used in a different field (i.e., agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering).

SUMMARY

The inquiry-training process created by R. J. Suchman is the foundation of inquiry. Inquiry was created as a structured, cognitive method for fostering and guiding student curiosity in the classroom. The inquiry-training process is a proven instructional strategy for students in varying grade levels, subject areas, and ability levels. There are five phases in the process. The first phase occurs when the problem is introduced to the student and the steps of the inquiry process are reviewed by the teacher. The second and third phases often occur simultaneously when the students begin gathering data through problem verification and experimentation. The fourth phase occurs when students present their findings. Analysis of the process, the final phase, is important for making sense of new knowledge and creating future inquiry sessions.

Early use of inquiry in technology education focused more on the use of tools, materials, and technical processes than on cognitive processes. Now, the *Standards for Technological Literacy: Content for the Study of Technology* say students should know how to use, manage, assess, and understand technology. The rapid advance of technology and limited classroom resources, however, have made it difficult for teachers to keep up with the latest tools, materials, and technical processes. Thus, inquiry-training is an effective instructional strategy for implementing the Standards because it provides students with a cognitive strategy to learn about technology.

DISCUSSION QUESTIONS

1. Why is inquiry-training an important instructional strategy in today's technology classroom?
2. How does the inquiry-training instructional strategy relate to the *Standards?*
3. What are some of the advantages of using the inquiry-training model and why?
4. What are the five phases of inquiry-training as an instructional strategy and why are they important?

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Cooperative Learning in Technology Education

Chapter
9

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INTRODUCTION

Baseball: it's the great American pastime. You've been playing since you were a kid. It's the championship game, bottom of the ninth, two outs, the game is tied, and you're on third. Your goal is the same as the team's: to win the game and the championship. The batter is up and he hits a shallow ground-ball single. You know it's going to be a close play, but the team yells for you to run, slide into home plate. When you take off running, all your team is screaming. The throw is close as you slide into home plate. Dust flies everywhere as the umpire yells, "Safe!" Your team runs up to congratulate you and everyone is still screaming, "You've won the championship!" However, as you try to get up, you feel the pain, you know you are hurt, you can tell that the bone is broken.

An hour later you are at the hospital in the operating room. You look around and see the surgeon getting ready, the anesthesiologist at the head of the bed, the scrub nurse next to the surgeon, and another nurse circulating around the room. They all assure you that it's going to be all right, that it's time for you to go to sleep.

While you are asleep, the operating room team works together with one goal in mind: to make you better. They are working together, each person performing his or her individual responsibilities, in a cooperative effort to make sure you get the best treatment possible. They are all in constant communication with each other and cooperatively working together as a team.

Cooperation is part of our daily lives. In fact, very few occupations, or sports for that matter, are individual efforts. Every day, people work in teams, which are most effective when all the members work together and do their part. As a part of teamwork, cooperation is very important skill that young people must learn. And where do they learn about it? They learn about cooperation through cooperative learning.

PURPOSE

In cooperative (or collaborative) learning, students work together in small structured groups to achieve a shared goal. However, cooperative learning involves much more than simply placing students in a group and instructing them to complete the activity. To be effective, cooperative learning must be properly structured and implemented. The major purpose of this yearbook chapter is to describe how to effectively structure and implement cooperative learning into the technology education classroom.

COOPERATIVE LEARNING RESEARCH

With the release of the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) it became evident that technology education teachers would be involved in revising curricula to reflect a strong emphasis on students being engaged in discussion, problem-solving, research, and the design and development of technological devices. Whether students are engaged in discussion, solving a problem, or designing a device, the implication is that students will be interacting with each other and the teacher in order to accomplish the learning task. Humphreys, Johnson, and Johnson (1982) assert that the way in which students interact with each other as they learn may be just as important and have a greater impact on students' performance than perhaps the new curriculum.

Deutsch (1962) first conceptualized the three types of interpersonal goal structures that are typically used in classrooms: cooperative, competitive, and individualistic. These goal structures specify the type of interdependence (i.e., depending on each other to survive) that exists among students as they strive to accomplish learning goals. In a cooperative goal structure, students work in small groups to accomplish a task and are usually rewarded based upon the performance of the group. In a competitive goal structure, students compete against each other for a limited number of rewards (e.g., grades, teacher praise, or winning a competition) and in an individualistic goal structure, students work alone, work at their own pace, and are rewarded according to their individual efforts (Johnson & Johnson, 1987; Slavin, 1990).

Many researchers agree that in the ideal classroom, each of the goal structures should be appropriately used. Students need to learn to work collaboratively, compete for fun, and work on their own. However, extensive research comparing each of these goal structures (e.g., Bossert, 1988–89; Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Qin, Johnson, & Johnson, 1995; Slavin, 1983, 1990, 1991) indicate that students participating in cooperative learning environments perform as well or better than students in competitive and individualistic learning environments on measures of achievement and attitudes toward learning.

COOPERATIVE LEARNING PRINCIPLES

Despite the well-documented benefits of using cooperative learning structures in the classroom, many teachers who have enthusiastically put their students into learning groups have been discouraged with the results: "Cooperative learning is too hard to implement and too time consuming" or "I've tried cooperative learning and it didn't work for me." Why have researchers and many teachers found cooperative learning to be so effective while other teachers have struggled with its use? A review of the cooperative learning principles could help these teachers understand that the key to cooperative learning's effectiveness seems to be the way in which the activity or assignment is structured.

Setting Up a Cooperative Learning Environment

Proponents of cooperative learning will tell you that simply putting students into groups and asking them to complete an activity does not mean that the students will work cooperatively or that they even know how to cooperate. Most of students' educational experience has been spent sitting passively rather than being expected to share their ideas with others; as a result, they may be uncomfortable working in cooperative groups at first. In order for an activity to be considered cooperative, cooperativeness needs to be structured into the activity. In fact, if cooperativeness has not been specifically structured into the learning activity, then research has shown that a cooperative goal structure is not necessarily better than a competitive or individualized structured activity (Slavin, 1990).

Slavin (1991) comments that two elements are essential for the positive effects of cooperative learning to be realized. First, the cooperating groups must have a group goal that is important to them. In our baseball example, the group goal of the team was to win the game. Group goals enable students to have an investment in one another's success and are necessary in order to motivate the students to help each other. The second element mentioned by Slavin is that the success of the group must depend on the individual accountability of all group members. In the baseball example, each member of the team—catcher, shortstop, or center fielder—had a specific responsibility to perform if the team was to succeed. In the technology classroom, activities must be structured so that each member of the team has specific responsibilities and is thus accountable to the team.

Johnson, Johnson, and Smith (1991) have further elaborated the conditions that must be structured into the classroom if cooperative learning strategies are to be effective: (a) clearly perceived positive interdependence, (b) considerable promotive (face-to-face) interaction, (c) clearly perceived individual accountability and personal responsibility to achieve the group goals, (d) frequent use of the relevant interpersonal and small group skills, and (e) frequent and regular group processing of current functioning to improve each group's effectiveness.

Positive Interdependence

Positive interdependence exists when the success of one person depends upon the success of another. To accomplish positive interdependence students working in cooperative groups must have a mutual goal they are working toward. In addition, each student is typically given a specific task or role within the group (divisions of labor). A common strategy is to divide materials, resources, or information among group members so that the group must pool resources to achieve tasks. For example, teachers should give out only one design brief to the group so that they must discuss materials together.

Another method used to encourage positive interdependence is to ask one person from the group to represent the group in explaining a concept or ideas the group has generated. Since the group does not know beforehand who this person is, they must get together and make sure all persons in the group are prepared to present.

Finally, the reward or grading system can also be used to foster interdependence among members of a group. A common approach is to award a group grade for the group project, in addition to presenting an individual grade for any quizzes. Also, bonus points can be awarded to the group if all group members successfully complete the evaluation higher than a pre-set level (e.g., the teacher states that if all group members score higher than 80% on the quiz, the entire group will receive bonus points).

Face-to-Face Interaction

To obtain meaningful face-to-face interaction, the size of the group needs to be small (from two to five members). A perception that one's participation and efforts are needed increases as the size of the group decreases. When students are involved in designing a solution to a problem, the design stage that involves generation of ideas is a good occasion to have larger groups of four to five. However, when tasks have been differentiated (i.e., performing research, building prototypes), a smaller group of two to three students is preferred. Finally, when establishing student groups, it is recommended that the teacher assign students to groups rather than have the students pair up with their friends. When friends pair up with friends, the group is usually not as effective as teacher-assigned groups because of the amount of "goofing off" that always seems to occur when friends get together.

Individual Accountability

Students will often "free ride" unless they are held accountable for their individual responsibilities within the group. As mentioned earlier, division of responsibilities is critical. One effective way of accomplishing this is to use "Team Contracts." With a team contract, the group determines the specific tasks that will need to be performed and then assigns members of the group to these tasks. Once a document is produced, the students sign their names to the contract next to their responsibility. The teacher also signs the contract, which is displayed in the work area. The teacher can then assess if individuals are contributing to the group through observation and individual testing on concepts. The teacher should also give positive feedback when students are cooperating and model correct behaviors to the students if they are not working interdependently. An additional strategy that is used to promote accountability is to have the members of the group anonymously rate the contributions of other group members.

Interpersonal and Small Group Skills

Placing socially unskilled students in a learning group and telling them to cooperate does not guarantee that they are able to do so effectively. It often takes time for teachers and students to feel comfortable in cooperative group settings. Students must be specifically taught the social skills for high-quality collaboration and be encouraged to use them. The teacher should assume an active role by moving from group to group modeling effective teamwork skills such as consensus making, active listening, taking turns, and working together. Also, it is helpful for the teacher to establish classroom rules for group behavior: use consensus to settle disagreements, listen to others' ideas, give everyone a chance to submit ideas, and contribute every idea—it may provide a solution to the problem.

Group Processing

Group processing requires the students to reflect on how well they, as a group, have been working together. This often involves the use of a questionnaire asking the students to list several things that they did as a group during the class that were productive and then list one thing they still need to work on in order to become a more effective group. The teacher then meets with the group and conducts a discussion of what he or she noticed that was productive.

COOPERATIVE LEARNING APPROACHES

As cooperative learning has gained popularity in the classroom, educators have promoted various approaches in which cooperative learning can be most effectively implemented. Cooperative learning can be as simple as stopping in the middle of a class discussion, putting a problem on the board, and asking students to work on it. The cooperative learning approach just described is called "think-pair-share." For example, a technology education teacher is presenting a lesson on recycling, stops in the middle of the discussion, and presents the class with the following problem: "What are we going to do with all the old outdated computers that are beginning to 'stack-up' in offices and warehouses?" In a think-pair-share situation, the teacher would ask students to do the following:

- first think about the problem and write down their own ideas on how to solve the problem.
- then pair with the person next to them to compare notes and devise a solution to the problem using both of their ideas.
- finally, share their solution with the class (Smyser).

Many types of cooperative learning approaches and variations of these approaches are currently being used in the classroom. It is beyond the scope of this chapter to cover all of these approaches. To help the reader gain a better understanding of basic cooperative learning principles, this chapter will describe a few popular approaches that can be adapted for use in the technology education classroom. These approaches include think-pair-share (already described), jigsaw, and academic controversy. To learn more about cooperative learning and cooperative learning approaches, the reader is encouraged to visit the following Internet sites:

- Kagan Publishing and Professional Development: www.cooperativelearning.com
- The Cooperative Learning Center at The University of Minnesota: www.clcrc.com
- The International Association for the Study of Cooperation in Education: www.iasce.net

Jigsaw

In a jigsaw puzzle, all pieces must "fit" together for the puzzle to be complete. The jigsaw approach is appropriate in an activity where students are required to find and present information on a selected topic. In the jigsaw cooperative learning approach, each student becomes an "expert" on one topic and shares that information with the group who then also become experts on the topic.

The following presents an example of using the jigsaw approach. Choose a topic or theme for the class to learn about (for example, choose Standard 14 from the *Standards for Technological Literacy: Content for the Study of Technology,* "medical technologies," specifically, the benchmark related to advances and innovations in medical technologies used to improve healthcare). Break the class into equal group sizes (e.g., four students per group). Assign each member in the group a different topic to research and become an "expert on" (e.g., student #1 researches X-ray machines, student #2 researches magnetic resonance imaging—MRI, student #3 researches computerized tomography—CT, etc.). Assign the same topics to all groups in the class. Have all the students with the same topic from each group meet and become experts on the topic (e.g., all #1 students would get together to research the operation and use of X-ray machines). Once students have become experts on their topic, they return to their original group to share and explain what they have learned. In the end, all students in all groups have become knowledgeable about the topic. Thus, in the example presented, all students in the class would be able to describe the use and operation of specific equipment used to improve healthcare (Kagan, 1994).

Academic Controversy

Almost all technologies present an academic (or intellectual) controversy that people can debate. For example, "Should we build new nuclear power plants to meet our ever growing energy need?" This question presents students with an opportunity to take a for (pro) or against (con) approach to the issue or topic being presented.

In the academic controversy cooperative learning approach, groups are formed that have an equal number of members (e.g., four students to a group). The group is then presented with a topic that has clear "pro" and "con" positions. Two group members represent one cooperative learning team and are assigned to research and find information on the "pro" position of the topic, while the other two students are required to research and find information on the "con" position of the topic. The group then meets to allow each team to present its arguments. This discussion allows for a critical analysis of the topic. After the team "arguments" have been heard, the teams reverse their positions and argue again "for" and "against" the topic. Finally, the teams come together and try to form a consensus on the topic that they present to the class or document in a report (Johnson, Johnson, & Holubec, 1994a).

The academic controversy approach is well suited when teaching about the Standards 4–7 related to the category "Technology and Society" of the *Standards for Technological Literacy: Content for the Study of Technology.* The academic controversy presented above is specifically related to Standard 4 where students have the opportunity to develop an understanding of the cultural, social, economic, and political effects of technology.

IMPLEMENTING COOPERATIVE LEARNING APPROACHES

While most educators would agree with the benefits of using cooperative learning in their classroom, implementing cooperative learning principles into existing curriculums is often an overwhelming task. Attending one-time in-service opportunities or reading a book on cooperative learning approaches does not usually provide teachers with a foundation strong enough to revamp their entire curriculum to reflect a cooperative learning approach.

If teachers desire to implement cooperative learning opportunities for the students in their classroom, they can engage in a workable process.

First, the teacher should become familiar with cooperative learning literature. Johnson, Johnson, & Holubec (1994b), Slavin (1990), Kagan (1994), and others have written introductory cooperative learning books that are helpful to those wanting to implement cooperative learning into their classroom. If possible, attending a class or in-service on cooperative learning would also be helpful.

Second, teachers should consider implementing some of the cooperative learning structures recommended by Kagan (1994) and others. These "structures" are well-defined techniques, such as think-pair-share, that are easy to learn and can be quickly implemented into existing lesson plans and classroom activities. Because of their user-friendliness, these cooperative learning structures have gained much popularity in the educational community with many related Internet web-sites including list-serves dedicated to helping the novice teacher implement cooperative learning into their existing classroom structure.

Once the teacher and the students begin to feel comfortable with cooperative learning structures, a more conceptual cooperative learning approach, such as those mentioned by Johnson, Johnson, and Holubec (1994b), Aronsen and Patnoe (1997), and Slavin (1990), might be incorporated. Jigsaw and academic controversy are both examples of a conceptual approach that consists of a framework that teachers learn and use as a template to structure cooperative lessons and activities. Although more difficult to learn and implement, once mastered, these conceptual approaches are often more robust and can have a greater impact on student achievement than the use of cooperative learning "structures" (Johnson, Johnson, & Stanne, 2000).

RELATIONSHIP OF STANDARDS TO COOPERATIVE LEARNING

Cooperative learning strategies can be effectively incorporated into the teaching of content identified in the ITEA (2000) *Standards for Technological Literacy: Content for the Study of Technology.* When designing standards-based activities and experiences, cooperative learning strategies can be used in any situation where the teacher feels that the use of teams would strengthen the learning experience. For example, cooperative learning approaches can be used when teaching about any of the *Standards* related to the designed world. In the designed world category, a cooperative learning approach could be used to help students learn about medical technologies or agricultural and related biotechnologies. Also, cooperative learning strategies are very appropriate when using the *Standards* related to the categories of design and abilities for a technological world. For example, a cooperative learning strategy could be used to help students come up with the best solution in the development of a new product or system.

COOPERATIVE LEARNING ACTIVITIES

High School Cooperative Learning Activity

Name of Activity: Video Production

Introduction:

In this activity, students will work in cooperative learning groups to shoot and edit a one-minute video production (e.g., commercial or public service announcement). The objectives of this activity are for students to learn the necessary preparation, organization, and technical skills required in a video production; to learn how to properly use a digital video camera and digital non-linear editing system; and to learn how to successfully complete a group project.

Cooperative Learning Strategy:

The teacher will give presentations and information on types of video productions, video formats, script writing, correct use of the video camcorder, and use of the non-linear video editing system. Students will be broken into groups using the following cooperative learning guidelines:

- The teacher will randomly assign students to groups of three to four students.
- Each student will be assigned specific responsibilities (e.g., camera operator, audio engineer, etc.) within the group and be required to become proficient in that area. The teacher will discuss with each group the importance of setting goals and objectives for the group, and that all group members must be involved for the group to succeed.
- The teacher will discuss evaluation of the group's project (e.g., in this activity, all group members will get the same grade on his or her video production).

- The teacher will discuss group dynamics and how to handle problems (e.g., if someone is not doing his or her job).

Standards Addressed in the Activity:

Standard #17: Information and Communication Technologies. In order to select, use, and understand information and communication technologies, students will learn that there are many ways to communicate information (i.e., students will learn how to use audio and video equipment), and that information and communication systems can be used to inform, persuade, entertain, manage, and educate.

Standard #12: Use and Maintain Technological Products and Systems. Students will learn how to use and maintain technological products and systems (i.e., students will learn how to operate and maintain audio and video equipment).

Standard #13: Assess the Impact of Products and Systems. Students will learn how to assess the impact of products and systems (e.g., students will be able to discuss the advantages and disadvantages associated with analog and digital audio and video equipment).

Middle School Cooperative Learning Activity

Name of Activity: Water-Bottle Rocket Design

Introduction:

In this activity, students will work in cooperative learning groups to design and build a water-bottle rocket as a solution to a problem presented in a design brief (e.g., design a rocket that will [a] reach a given height, or [b] remain airborne for the greatest amount of time, or [c] strike an object when launched at an angle). The objectives of this activity are for students to learn that design involves a set of steps and that brainstorming is a group problem-solving design process. In addition, students should learn that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions and that transportation vehicles are made up of subsystems that must function together for a system to work effectively. Finally, students should learn how to properly use small hand tools, as well as how to successfully complete a group project.

Cooperative Learning Strategy:

The teacher will introduce the activity and discuss with the class general principles related to the activity (e.g., engineering design processes, Newton's Laws of Motion), evaluation of the activity (e.g., group grade for rocket design, but individualized quiz score on related information), and the concepts associated with brainstorming, consensus making, and effective teaming. Students will be broken into groups using the following cooperative learning guidelines:

- The teacher will randomly assign students to groups of three to four students.
- Each group will be given a design brief and team contract related to the activity. On the team contract will be listed three to four specific responsibilities (e.g., launch operator, aerodynamics engineer, construction foreman) in which the students will need to become "experts" in order to perform the activity. The students will determine who is accepting which responsibility and have each team member sign their name next to that specific responsibility. The team contract is signed by the teacher and displayed in the work area.
- The experts then meet with experts from the other groups and learn the information related to their individual responsibilities. For example, the aerodynamics engineers will learn about drag, center of mass, center of pressure, and ways these are affected by wing shape, nose cone design, and the amount of water used when launching the rocket. The launch operator will learn how to safely operate the launcher and how to determine the height of the launched rocket while the construction engineer will gather and learn how to use tools and supplies need to build the rocket.
- The experts will then come back together and share their knowledge with the other team members. The teacher will reemphasize the importance of effective teamwork, i.e., all group members must be involved for the group to succeed.
- As a group, the students will go through the engineering design process to develop their solution to the problem.

Standards Addressed:

Standard #9: Engineering Design. In order to comprehend engineering design, students will learn that design involves a set of steps, which can be performed in different sequences and repeated as needed; that brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum;

and that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Standard #18: Transportation Technologies. In order to select, use, and understand transportation technologies, students will learn that transportation vehicles (e.g., rockets) are made up of subsystems that must function together for a system to work effectively.

SUMMARY

Cooperative learning includes a variety of "structured" learning strategies with the basic premise of using small groups with all members working together to achieve a common goal. It is a very popular instructional strategy that can be used to teach about topics related to technology.

To be effective, cooperative learning must be carefully implemented and maintained by the teacher. Consideration must be given to the teacher's teaching style, the student's learning styles and the content of the lesson. Finally, research has shown it to be a beneficial instructional approach to use in the classroom. It has been shown to help students grow intellectually and to enhance their social and personal development.

DISCUSSION QUESTIONS

1. Why is cooperative learning an important instructional strategy in our world today?
2. What are three types of cooperative learning approaches that can be used in the technology education classroom?
3. What are five important principles of incorporating cooperative learning in the technology education classroom and why are they important?
4. After reviewing the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000), what are five topics that could be taught using the cooperative learning approach as an instructional strategy?

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Web-based Instruction in Technology Education

Chapter 10

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INTRODUCTION

The use of media has existed in education for a long period of time. Radio in the 1930s, television in the 1950s–1960s and the advent of computer-assisted instruction and computer-based instruction in the 1980s. The computer was a new innovation that was supposed to give teachers the ability to individualize instruction. In the 1980s, the personal computer continued to provide enthusiasm for individualized instruction (Gilbert, 2001). No form of media has made more of an impact on both teaching and learning than the information accessible via the World Wide Web referred to in this chapter as the Web.

As technology educators, we must learn to use the Web for both teaching and learning. According to Gilbert (2001), "The new challenge for students, faculty, staff, and administrators is to learn how to take advantage of too many options" (p. 28). It is important, in this day and age, that the use of the Web be used to enhance what we do in the classroom. As indicated in the *Standards for Technological Literacy: Content for the Study of Technology*, "With the growing importance of technology in our society, it is vital that students receive an education that emphasizes technological literacy" (ITEA, 2000, p. vii). Using the Web as an instructional strategy in technology education gives both students and educators the tools to teach and learn, and opens dimensions in the field of technology education that were not possible just as recently as the 1990s.

With the increased interest and growth in the Web within our society, universities are implementing Web-based delivery of course material from units of instruction to entire degree programs. In addition, in high school programs students and teachers are accessing the Web for finding additional technology information, and in some cases, publishing information that supplements instruction.

PURPOSE

The purpose of this chapter is to explain Web-based instruction, also known as both e-teaching (electronic) and e-learning. This chapter will address the definition of Web-based instruction, the design and implementation of the strategy, and the relation of the instructional strategy to the *Standards for Technological Literacy: Content for the Study of Technology.* In addition, this chapter will also identify possible activities that can be used to enhance the technology education classroom by taking advantage of Web-based instruction.

DEFINITION OF WEB-BASED INSTRUCTION

Web-based instruction is defined as delivering or acquiring information via the Web as opposed to a traditional teacher-centered classroom environment. Web-based instruction is usually divided into one of two categories, Web-based or Web-enhanced. Web-based instruction means the entire content is delivered via the Web. Typically no face-to-face interaction takes place. Web-enhanced instruction would involve some of the content being delivered via the Web. A typical example is teachers using the Web as a supplement to their regular classroom teaching. The literature shows that both Web-based instruction and Web-enhanced instruction are being used more and more each day.

DESIGN OF WEB-BASED INSTRUCTION

In all instructional strategies, the design of the instruction is important; however, in Web-based instruction it is critical because often limited or no feedback from the students occurs. This section will address the design and delivery of Web-based instruction from both a teacher and learner perspective.

Pedagogical Model

When designing Web-based instruction, it is important to first formulate a pedagogical model. A pedagogical model is a framework or philosophy around which a course, unit, or activity will be designed. Ritchie and Hoffman (1997) pointed out a tendency of Web users to get distracted and/or sidetracked. Teachers who use the Web for educational purposes must clearly state the goals of the instruction. Web-based learners must know what they are expected to be responsible for which helps them to focus during learning experiences. Once students understand the expectations, the teacher needs to determine the capabilities of the students and the teacher. Faculty should ask themselves: Should the Web be used to supplement what I am currently teaching? Could the Web replace delivery of the content as it is currently being taught? What information is available via the Web that will enhance the delivery and content that is in alignment with the instructional goals and objectives? Is the content that will be taught on the Web identified in the *Standards for Technological Literacy: Content for the Study of Technology?*

Wegner, Wegner, and Holloway (1999) found that online teachers who use the Web for instruction must adjust their thinking to become a facilitator, guide, communicator, and resource person, taking on the role not of sage (man of wisdom) but of supporting guide. They also found that "relinquishing of control was found to be extremely disconcerting to online instructors in the beginning" (p. 12).

Effective Web-based instruction should be more than just publishing a Web page with course material on it, such as the syllabus. Many elements of effective instruction can be incorporated into technology education courses that are delivered via the Web. For a typical example, an audio track of lecture material combined with streaming text of lecture notes, streaming JPEGs (still pictures) of lecture slides, and video clips of demonstrations or illustrations dealing with the technological topic at hand show some of the elements that can be included in a course delivered via the Web.

Traditional Content Verses Web Content

Xiaoshi (2000) found four suggestions in making the connection between face-to-face-learning and Web-based learning. First, material and delivery must be adapted specifically for the on-line environment. Although this seems like an obvious statement, faculty cannot simply reproduce their material in an electronic format. As mentioned earlier, the needs of on-line students differ from those in the classroom.

Second, the design of a course or activity must be in phases, both immediate and long term. The course designer (teacher) must recognize that the course may be used in the future and may be used by different instructors. Additionally, instructors must be very careful to examine the entire content of Web-based courses, especially with regard to the implications of their changes in assignments from traditionally delivered practices to Web-based delivery.

Third, the course content must be designed in a systematic, logical, and consistent manner. If a course is not systematic, the traditional classroom teachers can go back and revisit material, as well as use varying teaching styles from day to day to make it more systematic. However, in the Web-based environment, teachers must thoroughly plan all instruction in order to avoid confusion and not hinder learning before the course starts, especially considering that the teacher cannot make needed changes along the way.

Finally, the teacher must take into consideration the computer hardware and ways the learner will physically access the Web-based information. This will be discussed in the next section in detail. However, teachers should be encouraged to avoid the use of "fancy" features just for the sake of being on the cutting edge of the computer technology. In most cases, these fancy features will be lost or unused because many of the students will not be able to access them or access would be very slow with their particular computer server or network.

Considerations for Web-based Learners

The Internet has significantly facilitated Web-based instruction and is, thus, provoking tremendous change and experimentation in how education can be delivered. Before embarking on Web-based instruction, several things should be considered. The following are some examples of such considerations for different learning environments. They are divided into the learner and the teacher.

Many things should be considered when designing curriculum for the learners in a Web-based learning environment. Xiaoshi (2000) made several suggestions for teachers that use Web-based instruction. First, the teacher needs to consider the type of students that will be involved with Web-based learning. Students who have a family, career, extra- and co-curricular activities, and a social life are more interested in the Web-based delivery system. Students can meet their educational aspirations at alternative times that are not in direct conflict with families, careers, etc. This implies that teachers should evaluate their course material with these conflicts in mind and remove any unnecessary material or assignments. However, it should be noted that Web-based instruction requires self-discipline, motivation, and great effort. Learning at home or at school via the Web presents many distractions to the learner. As described by Xiaoshi (2000), the most important relationship for Web-based instruction is between the instructor and the learner. Although the learner has most of the responsibility for completing the work, the instructor must also monitor the learning process so as to make adaptations or changes where confusion occurs. Again, this is typically an automatic function in the regular classroom, but in the Web-based environment student/teacher synchronous interaction is limited. Of utmost importance are communication and interaction, as well as the instructor's ability to make modifications to the instructional delivery to meet the diverse needs of students. These issues need to be planned into the ongoing responsibilities of the teacher.

Hidden Curriculum Considerations

In the 21st century, more and more students are being introduced to computer use early in life. With the number of home computers growing, as well as opportunities for computing skill development in the classroom, dependable computer skills are common. Unfortunately, it cannot be assumed that this is the case for all students. Web-based technology teachers must keep this in mind when considering their students. The importance of teacher support cannot be underestimated, especially with regard to students new to Web-based instruction.

Divergent educational paths also present themselves when addressing Web-based instruction. Teachers will find that as students progress through Web-based learning experiences, information will present itself that is not a part of the curriculum objectives. Diversions, also called "off the knowledge paths," are expected and must be closely monitored by the teacher. For example, learners conducting a Web quest (an activity where a student has a list of technology education pieces of information that they search for via the Web) may search for information relating to the history of the facsimile machine to find a Web site where they could view prices and purchase a fax machine. The additional information accessed through such a search may be good and important to the students, but will increase the time required for meeting the course requirements.

Many other hidden curriculum considerations need to be addressed, such as the need for basic word processing skills like cut and paste, hot keys, and editing to name just a few that may alter the Web-based instruction quality. Lastly, Web navigation and navigation between programs become critical and are key skills for Web-based instruction success. These skills will greatly increase the speed at which students will access the information. The increased speed will decrease the frustrations often found with Internet searches.

Attributes of Web-based Instruction

Lewis and Orton (2000) identified five attributes of innovative Web-based instruction, hypothesizing that these attributes will likely have an effect on the acceptance and success of Web-based instruction in general: (a) relative advantage: to what extent is it better than the alternative? (b) compatibility: is the Web-based learning compatible with previous learning? (c) simplicity: how easy will the content be to learn? (d) trialability: will the learner have a chance to experiment or evaluate the methods? and (e) observability: are teachers/students able to see the result or view the outcomes? If technology teachers are to meet the diverse needs of learners, they must address each of these attributes carefully as they plan their Web-based instruction.

Physical Environments

When considering the Web-based learning experience, several physical things should be taken into account. If the learning is not going to be completed in one sitting, it is advisable to use the bookmark function of the Web browsers to keep track of progress. The Web-based learner should also consider the furniture to be used. Seating should be comfortable yet promote good computer use and posture (i.e., feet flat on the floor and back straight). The keyboard should be a comfortable distance from the body and the monitor should be a reasonable distance from the eyes. It is advisable to obtain a large screen monitor, which is known to reduce eyestrain. Another means to reduce eyestrain is to develop backgrounds on the screen that are a soft color, such as light blue or green. The learner should print out lengthy text documents for reading off-line rather than reading them on-line. Also an adequate workspace should be available for books or manuals so that there is room for spreading out documents. Finally, the computer and desk space should be designed to provide limited distractions from the surrounding environment.

Considerations for Web-based Teachers

When considering Web-based instruction, the teacher needs to examine many issues. Quality delivery of instruction must always be the goal. How well that goal can be achieved will depend upon several factors. It must first be determined if this instructional strategy is appropriate for the content to be delivered. If not, another strategy must be selected for the unit or course. The following are some examples of additional factors for different learning environments.

Level of Computer Literacy

In terms of computer literacy, it is important to consider the level of computer literacy for all teachers and students involved. This will impact the types of activities, amount of content, and speed of delivery that can be delivered through Web-based instruction. Typically, technology teachers tend to be more technically literate with computer technology. In addition, the traditional college student typically possesses relevant technical skills. However, computer skills with middle and high school students tend to vary. For example, some are very skilled while others possess few computer skills. Also, non-traditional and older students often face a gap in computer skills. To offset these varying computer skills, the most helpful and critical instructional elements for students in Web-based learning are (1) timely feedback from an instructor or a professor and (2) the quality tutorial materials for students who have never taken a Web-enhanced or Web-based course (Xiaoshi, 2000).

Level of Technical Support

Wegner, Wegner, and Holloway (1999) concluded that an important component for Web-based instruction is administrative and technical support for instructors and students alike. This also applies to faculty who are supplementing their instruction within the classroom through Web-enhanced instruction. Without appropriate and useful technical help, both the learner and the instructor will experience frustration and difficulties. The implications of this reality are two fold. Without the day-to-day often hour-to-hour assistance, the learning could be interrupted or cut off. Second, with regard to the learner, the educator must provide timely response(s) to technical questions as well as any tutorials or on-line help that may be of service.

Class Size

With regard to class size, Xiaoshi (2000) suggests that to optimize and allow for effective feedback, fewer than 30 students should be enrolled in each class. However, it is suggested that faculty keep the size of the class to 20 students, to allow for more "workable" loads. This size will be manageable without overwhelming the instructor or minimizing their effectiveness. Institutions must fight the urge to pack as many students into Web-based classes as possible. The financially driven tendency of higher education administration to maximize the class size must be tempered by insuring that the quality of Web-based courses remains high while still allowing the faculty to manage the course within reasonable time frames.

Assessing Web-based Instruction

Assessment is a critical component in any teaching, but even more so in the Web-based environment. The opportunities for students to "slip through the cracks" are well known and, thus, the instructor must be sure that each and every student is actually learning the necessary content. Ritchie and Hoffman (1997) noted that to increase the likelihood that students are actively processing the information teachers should require them to develop an "artifact" of their learning. These practical, authentic projects (artifacts) should be designed to accurately measure students' learning. As a Web-based course progresses, students, for example, can develop on-line portfolios to exhibit their learning. These portfolios offer not only a chance for students to present their work, but also for the teacher to evaluate and assess the students' achievement. Additionally, when assessing Web-based learning, teachers will typically experience a decrease in teacher/student interaction. Over time, students become more comfortable with the on-line interface and delivery techniques and eventually reduce the need for asking, "How do I do this?" In doing so, the interaction with students will be focused and relevant. Many of the forms of assessment used in traditional instruction will work well with Web-based instruction. The main thing to consider is that directions to the student must be clear and understandable on all Web-based instruction.

Instructional Tips

Many instructional tips can help the faculty develop and manage a Web-based course or a Web-enhanced lesson. For the Web-based instruction to maintain quality, it is recommended that the instructor have the content refined. This is typically accomplished by making sure that the faculty have taught the course content in a more traditional setting prior to developing the electronic delivery. Moving from a traditional delivery method to Web-enhanced and finally to a Web-based instruction is a good transition that allows for evaluation of all of the issues at a slower pace.

Many studies have been conducted on development time of Web-based instruction. Time availability is essential for successful Web-based instructional development. Some studies show that as much as 40% more time is required to develop and operate a Web-based course. The development time for Web-enhanced courses, however, will vary depending upon the percent of the course that is utilizing Web-enhanced instruction.

When designing a Web-based component or course, it is important to keep hyperlinks up-to-date. Often, over time, links turn out to be irrelevant, not functioning, or misleading. It is suggested that words such as "example," "non-example," "justification," or "relation" be used when working with concepts or principals, and "definition," "shortest path," or "alternative path" be used when teaching about procedures.

Xiaoshi (2000) found that students consider "good" teachers are the ones that plan the entire course or activity first, organize the materials and methods, and implement effective teaching strategies. According to all the feedback from the distance learners interviewed, Web-based instruction is effective, especially when the students are engaged interactively in a process of knowledge inquiry, technology application, and self-development in learning. Interaction between instructor and student should be based upon solving a real problem pertaining to the subject. Interaction between students should be a part of the design to facilitate collaboration.

Appropriate software should also be selected to facilitate the Web-based instruction being used. "The effective use of Web technology lies not in the form, but in its ability to serve specific instructional goals and desired learning outcomes. . . the focus must be on learning and what brings it about, not the mechanism of delivery, or the course production techniques" (Xiaoshi, 2000, p. 5).

WEB-BASED INSTRUCTIONAL SOFTWARE

The instructional strategy within any Web-based course is going to vary from instructor to instructor. The best recommendation is to keep it simple. The method chosen will be determined by the personal knowledge of the program by the developer and ease of access that the developer has to technical support. Programs such as *Blackboard®* or *WebCT®* make it much easier to develop a Web-based course rather than developing the course from scratch. Also, it is recommended to use development applications such as Microsoft FrontPage® or Macromedia DreamWeaver® for the development of the Web-based course. These programs enable course development without the need to know html or scripting languages.

Programs such as ClassAct® and ClassCampus® are recommended for Web-based management. These programs allow the teacher to track student competencies and provide other benefits, such as monitoring where students are in their course, grading, and progress reporting.

Many of these programs offer various components designed into the software. Zhao (1998) identified commonly used components in Web-based instruction. They are shown in **Figure 10-1. Web-based Software**

Figure 10-1. Web-based Software Components.

Program	Function	Example
Forum	A method that facilitates discussion, collaboration, and criticism. In this environment students and instructors alike are able to post ideas and writing to be discussed and critiqued. Typically this program is used for long-term or ongoing discussion or texts. Forum is an asynchronous messaging environment.	Each student produces a writing sample and posts it in the forum. Each of the other students reads and critiques the work.
Bulletin Board	Participants can post short messages or announcements. This program is not designed for long-term or ongoing work, but is very useful for shorter messages. Asynchronous.	Due date or testing date changes can be posted for students.
Chat	Chat is a synchronous environment where students, instructors, and/or experts can communicate in real-time. There are actually many programs that function in this way and which can be obtained easily and at no cost.	Student groups can meet and collaborate on solving a problem, discussing assignment details, or simply discuss ideas or concepts.
Test/Exercise Builder	Test/Exercise Builder is a program that allows the teacher to create tests or assignments which can be viewed, completed, and submitted very easily right from a Web page. Students simply fill in a blank or choose an answer from among several choices, and by clicking a button, submit the assignment.	As students move through the course modules, each assignment can be written or cut and pasted directly into the Web page and submitted to the teacher.
Materials Development Kit	Allows a teacher to develop and manage on-line materials including multimedia documents.	Programs of this nature make it much easier for the novice Web developer to begin the transformation to the on-line environment.

Components. The component or program is shown on the left with its function and appropriate examples following to the right.

In addition to these components, the literature suggests three methods of delivering content for Web-based instruction that instructors could use as a beginning point. The first is videotape. This asynchronous delivery provides a virtual studio in which instructors could lecture and give demonstrations. This would be the most convenient for new Web-based teachers because it does not involve much technical skill to create. However, the conversion of VHS to digital streaming can be complicated and time consuming.

The second method of content delivery is to use the World Wide Web or Internet. The use of html, Flash®, or other higher-end programming applications could be used for the development of text, graphics, assignments, and documents in the Web-based course. This involves more technical skill but with proper support can be a very effective development tool.

Finally, computer-based conferencing, both synchronous and asynchronous, provides the educator and the learners with the opportunity to share ideas, discuss them, and collaborate on solutions to problems.

DELIVERY OF WEB-BASED INSTRUCTION

Once the unit or course has been developed, issues that deal with the administration of the delivery of the content to the students must be addressed. Most important is the ability for information access by the students. Web-based instructors must monitor closely their pupils' spoken and unspoken calls for help. Web-based instructors should remember that sufficient tools must be available to students. Technology can greatly enhance Web-based instruction, but if students are not able to access the information due to hardware or software limitations, the quality of the learning process is reduced. Ways in which students are tracked and their ability to access the Internet are important decisions that need to be made when developing the unit or course.

Student Management

To achieve effective and successful Web-based instruction, technology teachers should employ a management system to keep records of student activity and progress. If a management system is incorporated, the system will provide technology teachers with the information they need to create a virtual community of Web-based learners. Each time students enter the on-line environment, they log in with a password that accesses their personal work, as well as grades, feedback, and any information stored. Additionally, as the students progress through the Web-based module, unit, or lesson, the program can, based on scores, take the student down different paths of learning. For instance, if a student does well on a pre-test, the program can direct the student on a fast track to complete the learning or can redirect the student to a higher level of learning. On the other hand, if a student does not do well on a pre-test, or even begins to encounter difficulties during normal learning process, the program can route the learner on a track that is based on the data received from the student's own pre-test. Such interactive applications can take them through a more detailed progression of information, as well as any remediation that may be necessary.

Connection Speed Considerations

As a general rule, the faster the connection speed of the network server, the better the delivery potential of Web-based instruction. Though modems had become common in households by the 1990s, of all of the Internet access methods, modem connections are the slowest. The faster WAN/LAN connections are more common in academic institutions. The future holds a great deal of potential for wireless satellite connection as well, which eventually will be the standard means of connection.

Key to the development of Web-based instruction is the connection speed available to the learner. Do not develop materials that are highly technical with large audio and video file sizes if the audience has a 24K connection speed. The tradeoff of wait time will outweigh the benefits of the delivery method. Also, if connection speed is fast, choose delivery methods that the networking infrastructure will support.

In most rural settings, the telephone line infrastructure is not capable of high-speed or even medium-speed connections. Many areas can receive only a 24K connection. This is extremely frustrating for the learner. Much learning time is lost due to waiting for a program or Web site to load.

RELATIONSHIP TO STANDARDS FOR TECHNOLOGICAL LITERACY

For this chapter, the relationship to the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) is simple: to provide an alternative means of delivery for the content in the study of technology. Though the *Standards* do not define the instructional strategies, they do define the content. Web-based and Web-enhanced instruction are delivery techniques that can be used by individual instructors.

The key in this chapter is that technology educators should attempt to stay on the cutting edge both in the content (identified in the *Standards for Technological Literacy: Content for the Study of Technology*) and in the delivery or strategy. Web-based instruction is just a tool. Elementary, middle school, high school, and university technology educators all would have various instructional strategies to deliver the content identified in the *Standards for Technological Literacy: Content for the Study of Technology.* The key is time to learn, grow, and expand his or her knowledge and be leaders in the field of technology education.

The opportunities for Web-based activities are many. Although the specifics will differ from teacher to teacher, the following suggestions offer a few basic ideas to get started. In the case of technology education classes, the teacher could develop safety lessons or procedures for Web-enhanced courses to accommodate the absent or transfer students. Vocabulary lessons could be fashioned for a Web presentation, again for the absent or transfer students, but also for viewing or studying from home. Content, such as the attributes of design, engineering design, and other such content in the *Standards,* could be published in an electronic delivery format to enable availability for those students who missed the lesson or need additional insight. Quizzes and tests can be used on Web-based courses or Web-enhanced courses where instant feedback can be provided to the learner. Also, the test data can automatically be transferred to the database (gradebook). Since considerable information is already developed on the Web about the areas of transportation, construction, manufacturing, and bio-related technologies, the instructor may create lists of "quests" for the students. In this case the instructor creates a list of topics or questions that need to be answered by information found on the Web. The students then go to the Internet and search out this information, which in turn provides an excellent learning opportunity.

SUMMARY

Many instructional strategies in the field of technology education can be found. Web-based instruction provides opportunities to deliver the entire content of a course (Web-based instruction) or to supplement traditionally delivered content (Web-enhanced instruction). Because Web-based courses are becoming more common at many levels of education, the World Wide Web is no longer a novelty. In fact, the use of the Internet for students is becoming common practice both at school and at home. In order to stay ahead of common practice, technology educators must take the time to acquire the necessary training for development of a course or unit for Web-based learning and begin to use the Web for enhancement or complete delivery of many of the *Standards.* University faculty can deliver many of their graduate courses and undergraduate professional pedagogical courses via Web-based instruction.

Connectivity (hardware connection) is one of the biggest issues facing quality Web-based instruction. However, it is getting better every day. Speed and access are always going to be an issue and must be considered with any Web-based course development. The type of delivery and the type of instructional strategies with Web-based instruction used are widespread and divergent. The key to success is that instructors must be open for suggestions and ideas, open for improving their computer literacy, open for taking the time for professional development to learn applications, and open for flexibility and adaptation as the Web-based course is designed.

DISCUSSION QUESTIONS

1. Why is Web-based instruction gaining popularity in today's education circles?
2. What is one of the greatest issues facing the acceptance and quality of Web-based instruction and why?
3. How will Web-based instruction change in its development by the faculty when considering different student populations?
4. What are some of the program components that can be found on Web-course software and how are they being used in the instructional process?

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Using Modular Environments in Technology Education

Chapter 11

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INTRODUCTION

The field of technology education is changing very rapidly. Nationally, more and more middle and secondary schools are converting their traditional industrial arts programs to contemporary technology education programs. One of the major changes we see as an instructional strategy for teaching contemporary technology is the use of *modular* technology systems, also called modular technology education environments. Modular technology systems are now used in many of the middle and secondary technology education programs throughout the United States. The use of modular technology systems means that middle and secondary school teachers use self-contained, modular units of technology instruction in the classroom. For example, a typical modular unit in the area of Alternative Energy would include an energy trainer, solar oven, solar panel, wind turbine, various consumable supplies, tools, and accessories, including computer and associated software.

Various modular units are available for both the middle as well as secondary school programs. As students complete various assignments through each modular unit, they continue to advance to higher-level content. Examples of some of the more popular modular technology units include Aerodynamics, Computer Problem-solving, Fiber Optics, Computer Graphics, Flight Simulation, Electronic Music, Robotics, CAD/CAM Technology, Fluid Power, Computer Integrated Manufacturing, Satellite Communications, Desktop Publishing, Virtual Reality, Biotechnology, Video Editing, CO_2 Raceway, Space and Rocketry, Air-track Vehicle, Radio Broadcasting, Artificial Intelligence, and Weather Satellite.

Generally speaking, each unit of instruction within a modular program should be linked to a database of competencies that provide for the development of both the *Standards for Technological Literacy: Content for the*

Study of Technology (ITEA, 2000), as well as high-performance workplace knowledge based on a foundation of basic skills, such as computation and literacy, and the ability to apply this knowledge, also known as SCANS (Secretary's Commission of Achieving Necessary Skills) (SCANS, 1991). In addition, all modules are directly related to accepted technology themes that have been established within the NCATE and CTTE's technology education specialty area guidelines (ITEA, 1997).

The importance of modular technology is part of technology education in that modular technology is developed by and for technology educators and that modular technology systems guide the student to conceptualize, experiment, and examine the principles of the major content themes of transportation, communications, construction, and manufacturing. In response to a global need expressed by educators, corporate leaders, and government officials, modular technology instruction helps to provide a technologically literate workforce. It also serves as a basis for developing informed career pathway choices. Modular technology instruction incorporates a multilevel curriculum that promotes the development of critical skills of teamwork, decision-making, critical thinking, logical reasoning, troubleshooting, problem-solving, independent research, and career exploration. Modular technology instruction helps students understand and assess the impacts of technology on society today in order to make informed decisions about how they will use, manage, and even create technologies for the future.

PURPOSE

This chapter is intended to accomplish several purposes. First is to investigate how modular environments work and operate. This chapter will also investigate how to better prepare teachers in the field of technology education to teach successfully, and thus accomplish the mission of a modular technology education environment. Furthermore, this chapter will identify additional life skills learning that is taking place other than technology content, as well as describe some of the advantages and disadvantages of teaching in a modular laboratory. Finally, this chapter will investigate how modular technology environments help to meet the *Standards.*

Several reasons provide support for presenting a chapter on modular technology and modular environments. First and foremost, as described in this yearbook, many types of instructional strategies can be used in the technology education classroom. Using modular environments is considered one of many instructional strategies that could be used by the contemporary technology teacher. Secondly, in the past several years, modular technology has become more and more popular in middle and high school classrooms. Today's new technology teachers, after graduation from college, may very well accept a teaching position in a school that has a modular environment. Also, a somewhat limited research base concerning modular technology classrooms is evident. Finally, a direct link between the use of modular technology as an instructional strategy and the incorporation of the *Standards* (ITEA, 2000) in the technology classroom appears to exist.

PROGRAM CHARACTERISTICS AND OPERATION

The characteristics and operation of modular technology environments will vary considerably depending upon the school. Variations will occur in the level of the program, the length of program, the number of modules available to the students, the academic level of the students, the number of students in class, and the way the course operates, among other things.

Modular technology classrooms can be seen in grades 6–12. However, most of the modular technology programs are used in middle school and early high school at the 6–9 grade level as feeders to career choices for both academic and technical fields. Although modular technology equipment is often provided for senior high school, it tends to be focused on technology systems, such as manufacturing or information technology. Further, technology education builds foundation skills necessary for successfully moving forward in the educational system. Thus, more interest and excitement about modular classrooms occur at the middle school level.

The number of modules that a school offers will vary. Generally, schools have anywhere from 3 to 16 modules available for student use. For example, middle schools in some states have from 3 to 4 modules. When schools have only a few modules the course curriculum is often supplemented with various types of additional technology education strategies and activities. For example, if a particular school had a module on the CO_2 car, the instructor may develop additional transportation or production activities that parallel that particular module. The following outline shows an excellent way to integrate both transportation and production/manufacturing competencies and topics into one activity:

CO_2 Car Unit

- Components of a manufacturing system
- Main characteristics of mass production
- Resources used in manufacturing
- Main manufacturing processes
- Design engineering and productivity
- CO_2 engines
- Friction and its effect on a vehicle's performance
- Design and build a prototype vehicle
- Build and test a CO_2 model car

In other cases, middle schools may have from 10 to 24 modules for the students to use. For example, in California, modular technology programs are designed so that each of the 16 state standards can be met through individual modules.

Another interesting component concerning the operation of modular technology classrooms is the use of a "student expert." In many modular classrooms, the technology teacher uses a student expert to help during the classroom period. This student expert in many cases has taken the class the previous year and is already very knowledgeable about the modular units and topics. In many cases the teacher has worked with the administration to allow such students to leave other classes and help out in the modular technology classroom. These so-called "student experts" can help the students when they have a problem with a module or if the students have difficulty understanding the directions of a module. In general, these students are in the classroom to help out the teacher whenever they are needed.

Many other characteristics of a modular technology classroom help to explain their operation. One characteristic is the number of classroom sections that are being taught. The number of sections taught in schools may range from one to six sections. In some cases, teachers are responsible for six sections with 25 to 35 students in each section. In other cases the technology education teacher may teach fewer sections but often still 25 or so students are enrolled in each section.

Another characteristic of a modular technology classroom is the length of the semester for a modular course. Modular courses can vary from 15 to 18 weeks of time. Clearly, it is important to have the right number of modules in relationship to the length of the course. To this end, often the modular technology education teacher will devise a rotation for the students. The length of time that each student rotates from one module to another will vary from 2 to 10 days, depending upon the length of the semester and the number of modules that are available.

It is important to note that most modular technology teachers have days set aside between each rotation called discover days, creative days, problem time days, enrichment days, catch-up days, etc. These extra days may vary from one day to several weeks of time. For example, schools that have fewer modules may have 7 to 10 discovery or creative days to allow the students to work on other technology activities. On the other hand, for schools that have a greater number of modules, the teacher may allow the students only one or two days for discovery and creative time. These discovery or creative days are very important because they give time for the students to internalize the module concepts and knowledge and to try out the module concepts learned by using other technology instructional strategies.

The equipment used in the modular technology classroom may be purchased from several suppliers or vendors. Some of the more popular suppliers and vendors include Lab-Volt Systems, Synergistics, Depco, Learning Labs (Applied Technology), Scan Tech, as well as teacher-created modules. Rather than judging each supplier or vendor, it should be noted that before purchasing any modular technology equipment, teachers should become thoroughly familiar with each product. Some of the variations between vendors and companies include the following:

- The depth of the software—Some companies design their software with more technical depth while other companies have less technical depth to the software.
- The levels within the software—Some companies have only one level of depth while other companies have up to three levels of depth with the third level being oriented toward creative design within the content of the module.
- The quality of the physical equipment—It is very important for teachers to be familiar with the quality of the physical equipment of the module. Some companies have high quality while other companies have less quality built into the physical equipment that supplements the software.
- The ability to alter or change the software—Some suppliers of modular equipment allow the technology teacher to alter and adjust

the software to their particular course needs and instructional techniques.

Each modular course often has it own title. Course titles can vary across the spectrum: Technology I, Technology II, Applied Technology, Exploring Science and Technology, Technology Education, Technology Applications, and Technology Design. It is important that the course title be appropriate for the particular school, as well as act as a marketing tool to draw students to the course.

INTEGRATED LEARNING SYSTEMS

Over the past ten years, many technology educators have become accustomed to referring to their programs as a *modules* program, or a *modular* program. In fact, most modular technology education programs are purchased by simply listing the modules that they would like to include in their program. This, unfortunately, relegates the selection process for a technology education curriculum to that used in selecting any commodity-type product.

Modular technology education programs should be purchased with an understanding that the modules provide one component of the total educational curriculum and instructional strategy. A technology education program needs to facilitate the delivery of a complete technology education curriculum that allows students to achieve a high level of technological literacy as well as the development of foundations for career pathways into a variety of occupations. In short, modular equipment should be seen as integrated learning systems or a part of the total technology education program. Thus, before deciding what modules to purchase, make sure to analyze how the modular components will fit into the total technology education program.

Integrated modular technology education programs have generated a fundamental paradigm shift in the teaching of technology. It has not only become important to change the way in which we teach, but also to keep the technological content current.

Today's modular technology education classroom most closely resembles a learning community. In their purest sense, learning communities help students link their academic work with active and increased intellectual interaction with each other and with the teacher. Learning communities also promote coherence among students and create a sense of common purpose and community. Learning communities are small subgroups of students characterized by a common sense of purpose that can be used to build a sense of group identity, cohesiveness, and uniqueness that encourage continuity and the integration of diverse curricular and co-curricular experiences (Matthews, Smith, MacGregor, & Gabelnick, 1997).

The teacher in this learning community is the master learner. The master learner is a teacher who takes the courses and fulfills all the requirements along with the students. The master learner or teacher then leads the seminar and assists students in synthesizing and exploring the opinions and points of view.

As stated in the *Standards* (ITEA, 2000), technology is how humans modify the world around them to meet their needs and wants or to solve practical problems. It is not enough to understand that a building, a ship, or cloning are all examples of technology. The understanding must go deeper in order to not only understand the world in which we live, but to become a productive member of society.

Modules alone cannot achieve this goal. A modular program requires an integrated learning system that includes several elements. These include the Computer Aided Instruction (CAI) modules, a management system for organizing the rotation of modules for the students, and an editing and authoring system for the teacher. These modular technology components must then become a planned part of the total technology curriculum.

TEACHER COMPETENCIES

Teachers of technology follow many paths to the classroom, including traditional, university-based programs, and countless other routes. Regardless of the path they choose, a technology education program needs to accommodate multiple levels of education that address both the needs of the teacher and the students. For the technology educator, this process starts with professional development. Professional development is a continuous process of lifelong professional learning and growth, from pre-service during the undergraduate years to in-service through the end of a professional career. If a technology teacher decides to develop a modular technology program, a professional development program must provide pedagogical and program management and assessment skills, increasingly sophisticated levels of content knowledge, knowledge of how students learn, and knowledge of how the modular technology laboratory operates.

When in-service technology teachers graduate from college and enter the educational workforce, they may enter into a variety of technology education programs. Today, it is very possible that recently graduated technology teachers may well be hired by a school district to teach in a modular technology environment. It is important for new teachers as well as experienced technology teachers to have the necessary classroom management competencies to be successful in a modular environment. Many competencies are needed. The following shows a description of the most common teacher competencies needed to function successfully in a modular environment.

First and foremost, teachers must know the equipment. It would be very difficult to teach in a modular technology environment if technology teachers did not have a working knowledge of the modules themselves. This can often be accomplished by having colleges and universities offer courses on modular technology in an undergraduate or graduate program. As part of this experience, future teachers come to know and understand the depth that is programmed into the software for each module. Knowing this can help the teacher better plan the modular technology program, including the extra activities and discovery and creative days. It is also important to note that most commercial modular technology programs have modular training as a part of the costs of purchasing a modular laboratory.

A second competency that is a must for all modular classroom teachers is that of classroom management. Of course, classroom management is important for all technology education teachers in all environments. However, in a modular technology environment the teacher must know how to manage a classroom with modular equipment, know how to keep all students challenged, on target, focused, and on task. Teachers must also know how to repair the equipment when broken and how to troubleshoot the software. They must also know when to add in the discovery or creative days, how to develop the creative activities, and how to keep each student challenged based upon the diversity within the classroom. Thus, a well-designed integrated learning system becomes very important. Management of a modular program made up of different and separate parts without being interrelated becomes very difficult.

Teachers who use modular technology must be able to think in an interdisciplinary manner, as well. Most of the modules sold today weave mathematics, reading, history, social studies, and science into the module software. This is especially true at the middle school level, where the modular technology teacher must have a "big" picture of technology. Modular technology at this level is very exploratory and not highly in-depth. However, it should be noted that the modules go into much more depth at the high school level.

Computer literacy and program network competencies are also very important for modular teachers to possess. Since many of the companies that develop modular technology components use computers and networking for test taking and grading purposes, these two competencies have become very important. Modular technology teachers must be able to understand computer networks, troubleshoot problems in such systems, load software, and be comfortable with computer systems in general.

In addition, teachers who teach modular technology must have a general knowledge in the technical area of each module. It is not necessary to have an in-depth technical knowledge in each of the module topics especially at the middle school level. However, at the high school level, more technical depth in the subject area of the modules would certainly be very helpful.

The modular technology teacher must also have ability to repair the hardware of the module. As with any other type of laboratory situation, technology teachers are often called upon to repair the laboratory equipment. In this case, rather than repairing a production machine, the modular technology teacher may have to repair the physical hardware that is part of the module.

Furthermore, the modular technology teacher must know how to get technical support quickly. In a modular environment, at times the teacher must contact the company or vendor that has supplied the equipment. In many cases, technical support is often needed quickly. Thus, the modular technology teacher needs to have the ability to contact suppliers and vendors when a problem arises. This too is where the same vendor of the modular technology program is advisable. If all software, curriculum, and module equipment are obtained from the same company, repair of the modules and access to service personnel are greatly enhanced.

As with any other technology education laboratory, the teacher must have an organized system for inventory control of the parts used on different modules. Depending upon the module, different parts, such as bolts, gears, valves, electrical components, weights, string, belts, plastic stock, etc., may be needed in different modular units. Such parts are often part of the instructor inventory control and, thus, must be organized as part of the inventory control system.

LIFELONG SKILLS/KNOWLEDGE LEARNED BY STUDENTS

Modular technology learning environments should offer the delivery of educational resources that consist of project-based cooperative learning materials, teacher lecture aids, and modules in a wide assortment of technology fields, such as communications, construction, transportation, manufacturing, and bio-related systems. Thus, the modules should be designed and offered in a contextual and relevant environment in which technology and lifelong learning skills and knowledge are developed.

Besides the technological content of each of the modules, significant lifelong learning skills and knowledge are being developed in the modular classroom. For example, since in all cases students work in groups, a great deal of cooperative learning is taking place. Cooperative learning helps to develop various social skills, respect for others, and ways to get along with students as described in Chapter 9.

Other lifelong learning skills are also being developed. For example, because of the nature of the modular environment, students also learn how to be a self-directed learner, a major skill for being successful in today's society. As part of being a self-directed learner, time management skills are being developed, as well. Such skills have a tendency to develop an increased sense of responsibility within the students.

Furthermore, other lifelong learning skills are being developed in a typical modular laboratory, including accountability (getting things done on time), an ability to stay on task (making sure to finish the module), computer literacy (becoming familiar with computer software), research skills (especially true in the high school modules), problem-solving (learning to solve module problems by themselves), and respect of technological equipment.

ADVANTAGES OF MODULAR TECHNOLOGY

A module technology environment boasts many advantages. For example, because of the design of the software and its content, students are able to see technology as a very broad field. This ties directly to the *Standards for Technological Literacy, Content for the Study of Technology* (ITEA, 2000). Several standards deal with technology from a very broad point of view. For example, Standard 1, The Characteristics and Scope of Technology; Standard 2, The Core Concepts of Technology; and Standard 3, Relationships Among Technology and the Connections between Technology and Other Fields all emphasize the broad nature of technology. Standards 4, 5, 6, and 7, which deal with Technology and Society, also emphasize the broad nature of technology.

In addition, students learn a variety of technical topics in the field of technology. Depending upon the number of modules, students can learn exploratory content in the areas of manufacturing, transportation, construction, communications, energy, and biotechnology, all of which are part of the *Standards.*

Learning can also be more efficient in a modular laboratory environment as compared to the traditional laboratories. According to a survey done by Schwaller (2001), teachers indicated that students could learn in one week what it took six weeks to learn before. One of the reasons for decreased learning time is that the software used in modules and the instructional strategies have been carefully and deliberately designed by technology education experts in the field.

There are a variety of other strengths when using modular technology. For example, time is always set aside for creativity in the "discovery time." Students enjoy and learn a great deal during these times. Often the creative or discovery time gives students the ability to try out new concepts just learned in the module. However, it should be noted that the teacher must facilitate this creative or discovery time very carefully. Such time should not be down time but time in which the student can engage in higher-order thinking skills concerning the content of the module. Within this yearbook, many other chapters discuss excellent instructional strategies that could be used during the discovery time periods.

Another advantage of modular technology is that the parents are often impressed with modular learning environments. When parents come into the laboratory the first time during parent/teacher conferences, for example, they can easily see that technology is much broader than previously thought. This has a tendency to change the perception that parents have concerning their definition of technology education. Modular technology environments have the ability to change the perception of our discipline to a more positive and contemporary image.

In addition, some modular technology software and network systems allow the computer to be used to select student groups. This allows the teacher to be objective about how groups are selected, which in turn encourages collaborative work as well as group dynamics skills, clearly another benefit.

Furthermore, modular technology systems allow a thorough assessment of student learning. Integrated management and assessment systems used on modular systems offer the ability to track student progress. A well-designed modular program should balance cognitive and performance assessment with other forms of assessment to provide an effective means to measure success. Well-designed assessments collect information on student learning, understanding, and capability and use that information to enhance learning.

LIMITATIONS OF MODULAR TECHNOLOGY

As with any existing technology education program, limitations also exist. Probably the most significant limitation of modular technology is that of equipment breakdown. Of course, this is true of any laboratory, whether it be a traditional, contemporary, or modular laboratory. When the equipment breaks down, or a module is no longer usable, a serious change in the organizational structure and management of the course occurs. Keeping in mind that the students are on a rotation, when a module fails, it will cause the teacher to readjust the rotation. In many cases, however, a teacher will plan for this readjustment by having one or two additional modules to help offset the problem.

Another limitation when using a modular technology environment concerns the discovery days. Without the discovery days, students have a tendency to become somewhat bored with the continuous process of rotating from one module to another. It must be remembered that modular technology, as an instructional strategy, is not designed to do all of the teaching for the teacher. It must be an integrated system. The teacher must still be a facilitator and design meaningful creative and discovery times for the students. As indicated earlier, some schools actually maximize the creative and discovery times and use modules only to supplement the days.

In some modular technology laboratories, several companies and vendors have been used to provide the modules. If the modular program uses modules from several vendors, and since each company or vendors' software is different in operation as well as depth, the teacher must learn the operation and depth of each company's products. This, of course, means more preparation time for the teacher before the class begins.

In the grouping of students (usually two students per module), different academic levels of the students often create a limitation. If an academically bright student is paired with an academically slower student, the brighter student might be held back while the slower student might learn more. On the other hand, this type of problem causes students to develop leadership and social skills as well. Often this type of grouping occurs in the real world and, thus, can be used as an advantage for the academically brighter student.

Other limitations deserve mentioning. Some of the more important limitations include the following:

- Continued administrative support from the school district is necessary including additional money to keep the module software up-to-date.
- The average costs of a modular laboratory will range from $80,000 to $125,000. Although a disadvantage, getting the administrative support for such a classroom seems to be feasible.
- Improved follow-up in the senior high school needs to occur. Often an articulated system for students moving from the middle school to the high school is not in place. However, some vendors have developed more in-depth modules and more problem-solving exercises and activities to help offset this problem.

MODULAR TECHNOLOGY AND THE *STANDARDS FOR TECHNOLOGICAL LITERACY*

The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) will change the field of technology education dramatically. This is also true with any type of instructional strategy. Schwaller (2001) conducted a survey to determine the relationship between modular technology instruction at the middle school and the *Standards.* This survey identified the opinion of 20 modular technology teachers in regard to the amount of learning taking place in reference to the *Standards.* Using a bi-polar scale from 1 to 5, with 5 representing a great deal of learning, and 1 representing minimum level of learning, each modular technology teacher was asked to respond to a 20-question survey. To aid the teacher in this process, the question was asked how much learning is taking place (in their opinion) concerning each of the *Standards.* The results follow in **Figure 11-1.**

Figure 11-1. Evaluation of Modular Technology Labs.

NATURE OF TECHNOLOGY		
Standard 1	The characteristics and scope of technology	3.90
Standard 2	The core concepts of technology	3.30
Standard 3	The relationship among technology and the connections between technology and other fields [a]	4.45
TECHNOLOGY AND SOCIETY		
Standard 4	The cultural, social, economic, and political effects of technology	3.10
Standard 5	The effects of technology on the environment [b]	3.80
Standard 6	The role of society in the development and use of technology	3.70
Standard 7	The influence of technology on history [c]	4.15
DESIGN [d]		
Standard 8	The attributes of design	4.45
Standard 9	Engineering design	4.15
Standard 10	The role of troubleshooting, research and development, invention and innovation, and experimentation in problem-solving	4.30
ABILITIES FOR A TECHNOLOGICAL WORLD		
Standard 11	Apply the design process	4.20
Standard 12	Use and maintain technological products and systems	4.10
Standard 13	Assess the impact of products and systems [e]	3.40
THE DESIGNED WORLD		
Standard 14	Medical technology	1.80
Standard 15	Agricultural and related biotechnologies	2.80
Standard 16	Energy and power technologies [f]	4.50
Standard 17	Information and communications technologies [f]	4.60
Standard 18	Transportation technologies [f]	4.25
Standard 19	Manufacturing technologies [f]	4.80
Standard 20	Construction technologies [f]	4.00

NOTES

[a] This was high because the software in each module deals with math, science, etc., as well as technology.
[b] Some laboratories had environmental module topics.
[c] In most cases, each module started with historical information about the specific topic being addressed.
[d] Since many of the modules enable the students to design and test a product, these three standards were rated very high.
[e] Rated a bit lower than other design standards because often the module did not go far enough in assessment of the product that was being designed.
[f] Ratings within the designed world in most cases were higher because there were complete modules that were related to standards 16–20.

SUMMARY

Although not without its problems, modular technology continues to expand into more and more middle schools throughout the United States. Based upon this research, several summary statements can be made. First, modular technology classrooms and environments work well if used as one of many instructional strategies in the classroom. Modular systems should also be considered an integrated system, not the one and only way to teach technology education. In addition, teachers placed in modular technology classrooms need to be trained and prepared correctly in order to be successful in this type of environment. Furthermore, many additional lifelong learning skills are developed in most modular classrooms. Also, modular technology classrooms help to meet many of the *Standards*. Finally, the modular technology equipment seems to be the biggest concern for many of the teachers in terms of keeping the equipment in good working order and up-to-date.

DISCUSSION QUESTIONS

1. Should a modular technology education program come from one supplier or vendor that designs the modules, the curriculum, and the assessment platform, or should the modular equipment be pieced together from multiple sources of equipment and software? What are the impacts of using one supplier verses many suppliers/vendors?
2. How important is integration of a modular technology program into the total technology program? Why is integration important and what effects would be seen if little integration occurred? What are some of the advantages and disadvantages of having an integrated modular system?
3. What is the best way for technology teachers to develop and incorporate a modular technology environment into their technology curriculum? What are some of the decisions that must be made and how will these decisions affect the modular program, as well as the total technology curriculum?

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Student Competitions in Technology Education

Chapter 12

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INTRODUCTION

Student competitions are a means to creatively engage the critical thinking of students in the technology classroom. In *Webster's Encyclopedia of Dictionaries* (Allee, 1981), a "competition" is defined as the act of competing, such as in a contest. Often used along with a competition is a challenge. A "challenge," on the other hand, is an invitation to a contest, to a duel, or to call in question. A challenge can present itself in various forms, such as different groups of students challenging each other to create the most efficient high-mileage vehicle, build the strongest bridge out of balsa, or complete a creative word problem in the quickest time. Thus, when a challenge is called in question, the competition is the process to accomplish the challenge; thus, such information can be used as an effective instructional strategy in technology education.

PURPOSE

The purpose of this chapter is to investigate the importance of using student competitions as an instructional strategy in the technology education classroom. In addition, this chapter will also study the components of competitions and how the competitions and challenges can be applied in the technology classroom. Finally, this chapter will investigate how student competitions, as in instructional strategy, relate to the *Standards for Technology Literacy: Content for the Study of Technology* (ITEA, 2000).

IMPORTANCE OF COMPETITION IN THE CLASSROOM

Competitions can be part of a classroom project or extra-curricular activity that causes the students working on the competition to use problem solving techniques, creativity, inquiry, and life skills. Student competitions can increase student participation, increase their excitement, and create a fun, non-threatening way to learn. Students have the potential to gain important social skills and technical literacy of equipment and processes used; create a sense of accomplishment; and improve their self-esteem. Student competitions, if done correctly, can be a great instructional strategy to address the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). This chapter investigates how and why competitions are used in the technology education classroom.

Competitions are an important type of instructional strategy to use in the technology classroom and tie directly to the study of technology. Hacker (1997) states, "Technology is the study of the human-made world. It is through this study that children come to understand and learn responsibility about how the human-made world functions. The way that children learn this is through design, that is, building, creating and affecting the world in which we live" (p. 7).

Competitions also help students to understand how technology affects their lives, decisions, and outcomes. Competitions help to engage the critical thought process in students, by means of presenting a problem with a specific set of criteria, a time line, and equipment needed to test their ideas. As indicated by FIRST in the *Technology Teacher*, "When students actively engage in the challenge, the result is [a] fun, exciting and stimulating environment in which all participants discover the important connection between classroom lessons and real-world applications" (FIRST, 1998, p. 22).

Student competitions not only allow the student to recognize new technological content through the activity, but also acquire the content of technology through the use of non-traditional instructional strategies. The study of technology education has specific content areas as well as content processes. Through competitions students have the opportunity to gain a wider knowledge base of the total field of technology.

Williams (2000) states an important consideration when using competitions:

> A relatively recent realization has been that there are many significant cognitive skills which are important for students to develop, and which are suitable to be developed in the unique context of technology education. The term unique is appropriate because there is no other curriculum area in which students have as significant an opportunity to think, reflect, develop ideas, and test their ideas in a practical context. The development of these cognitive skills occurs through the procedural knowledge of technology education. (p. 1)

When a solution to a particular competition is sought, the process of creating the solution is developed through procedural knowledge. Procedural knowledge is a skill that the students gain; it is a method of processing the students' practical classroom information without hesitation to complete their project. Students gain cognitive and procedural skills while working on their competition as an instructional strategy.

Motivating the students to learn, to participate, to be involved, and to invest themselves into such an important project is the first hurdle that teachers must overcome while developing either a classroom or extracurricular competition. Creativity, humor, fun, playing, and laughing are essential while the students engage in their competition. Without the ability to express themselves in a non-threatening environment, students' creativity and learning will be inhibited. In relationship with Standard 10 of the *Standards* (ITEA, 2000), "Creativity, in addition to an ability to think outside the box and imagine new possibilities, is central to the process of invention and innovation. All technological products and systems first existed in the human imagination (p. 106)." Allowing the students to have fun and express themselves in competition activities will increase their participation, involvement, and self-investment.

COMPETITIONS IN TECHNOLOGY EDUCATION

Student competitions are one of many types of instructional strategies that can be used in the technology classroom. Competitions require the application of a strong base of technological knowledge, along with problem-solving skills, that will enable the students to cope with new technologies, make informed decisions and adapt them to the ever-changing world (Christensen & Martin, 1992). This instructional strategy relies heavily on having the teacher shift from teacher-centered to student-centered instruction. In a classroom setting, where a competition is occurring, the teacher becomes a facilitator and gives students new technology knowledge on a need-to-know basis. Even though each student in the classroom may be working on the same problem, because it is a competition, not all students or groups will need the information at the same time. The teacher must step back and allow the students to gain the information as needed. If the teacher takes the traditional role of lecturer/demonstrator, the students would be predisposed to a certain kind of solution or process to the solution of the competition. Teaching this way will limit their creativity and lessen the motivation necessary to complete the task. It is important to remember that the teacher must allow the students to have time to go through the various problem-solving processes when they are involved in competition activities.

COMPONENTS OF COMPETITIONS

Although competitions and challenges are very similar, differences arise when used as an instructional strategy. As stated earlier, competitions are defined as the act of competing: a contest; while a challenge is an invitation to a contest, to a duel, or to call in question. The difference falls in the process that the technology teacher takes to complete the activity. This means that the teacher presents goals, objectives, and outcomes to the students as part of the competition rather than just competing for the final product. The teacher's goal is to encourage students to figure out the best way to answer the challenge. The teacher should encourage the students to become independent thinkers and to research and question the information. Many components comprise an effective competition in the classroom. Toward that goal, some questions that should be asked include:

- What are the students trying to solve?
- Are they solving a creative word problem?
- Are they designing a high-mileage vehicle?
- Are they re-engineering a machine to work more efficiently?

Challenges can be found in a variety of different forms. Also, remember that the outcome or final product is not the ultimate goal of a competition. The ultimate goal of a student competition is to understand the processes and the ability to create, design, and problem-solve a particular challenge that has been accepted by the students. When the competition is completed, students have pride in the work they have completed.

Students today are being bombarded with so much new technology that it is difficult for them to make sound decisions based on their knowledge. However, thorough preparation for the competition will allow the students to complete the challenge with success, while achieving a goal, becoming independent thinkers, and putting to use the processes of technology. In preparation for the challenge, the teacher should lead the group in an activity to engage their thinking skills. The goal of this part of the student competition is for the teacher to understand what the students know, and do not know and what information they have available from related areas. Woods (1987, p. 55) identifies three thinking skills, as they relate to technology education and student competitions, which may be classified as follows:

1. **Prior Technological Knowledge**—Knowledge and skills gained from previous study in a technology education class.
2. **Related Knowledge**—Knowledge gained from classes other than technology education such as mathematics and science.
3. **Knowledge Seeking**—Ability to identify missing information, and locate to obtain relevant information.

One of the goals of student competitions is to create an environment that allows the students to use higher-order thinking skills. At the beginning of the competition, the teacher encourages the students to recall information and knowledge. At this point, the teacher has engaged the students in lower-level thinking skills such as knowledge, comprehension, etc. Once the competition gets the students to apply technological content, analyze technological systems, create potential solutions, and evaluate these solutions, higher-order thinking skills are then being encouraged. In work done by DeLuca (1991, p. 2) he suggests five processes (all of which are considered higher-order thinking skills) that could occur when using competitions and/or problem solving. These include:

1. **Troubleshooting/Debugging**—Isolate the problem, identify possible cause, test, implement solution, test solution.
2. **Scientific Process**—Observe, develop hypothesis, experiment, draw conclusions.
3. **Design Process**—Brainstorm, identify possible solution, develop prototype, finalize design.
4. **Research and Development**—Conceptualize the project, select research procedure, finalize research, analyze result, report result, evaluate research project.
5. **Project Management**—Identify project goal, identify tasks to reach the goal, develop a plan to accomplish the tasks, implement the plan, and evaluate the plan.

The type of challenge that is presented to the students will determine which of the above processes the students or groups will use in the competition. Although the large group may work on one problem, each individual or individual group may use a different process at different times throughout the competition. Once the teacher has gone over what the students know, where they learned it, what they are missing, and then the five processes for solving a problem, the challenge is then given to the students. As a result, the students can understand the challenge and can start the process of the competition. Once the group gets to this point, communication grows among students, self/group responsibility for their project increases, and excitement and energy fill the room. Ultimately, teachers find themselves much more of a facilitator rather than an information giver because each group that has been challenged will need different things from the teacher at different times, the goal of the competition is for the students to gain independence from the teacher, to use the various processes that have been covered, and to complete the competition.

APPLICATION OF COMPETITIONS AND CHALLENGES

Competition Planning

Teachers beginning to design a student competition activity must consider many aspects as part of the initial planning. Planning for the competition may take hours in order to accomplish all the goals that the teacher has set because many external aspects must be addressed, such as the time factor. The teacher needs to ask questions about how much time the students will need to complete the competition and how much time they realistically have. Other questions that need to be considered include the following:

- What will be the cost of the competition?
- Where will the supplies come from?
- What supplies will be needed?
- Will supplies be limited so that each group has the same supplies or will it be open to whatever the students bring in on their own?
- What other resources are needed to complete the competition?
- Will the media center supply the information needed?
- Will the Internet answer any of the students' questions?
- Is there a need to make contacts from community experts to answer certain questions?

- With correct information, how can the students complete the competition with the most success?
- Does content learned in the competition meet state, national, or other standards?
- What standards are being planned for?
- How will it be documented if the standards are met?
- What role will each student play in the competition?

As teachers, we need to step back from the project and allow the student groups that have been challenged to go in many directions and allow the students to set up their own goals, process, etc., to accomplish the competition most effectively. After all the planning is completed, the teacher needs to compose her own goals, expectations, and process to help the students without hindering the students' creative processes.

Potential Problems

While the students are actively working on their competition, problems may arise. Consequently, the teacher must monitor the group, recognize problems, and adjust accordingly. Monitoring and adjusting will happen daily. For example, supplies may not be received in time or the weather may cause an issue if an outdoor competition is planned. The list of problems that may cause the competition to be adjusted is infinite. The teacher should be constantly aware of things such as the following:

- Identifying what stages of the competition the students are in.
- Knowing what supplies are needed.
- Keeping the communication open between teacher and students.

If monitored closely, issues that may arise from such problems will be much easier to solve. Monitoring and adjusting throughout the competition will occur, even with the best intentions and planning. As long as the teacher is prepared to make the changes, the monitoring and adjusting stages will cause minimum distraction to the competition.

Once the students are given the criteria for the competition, each group or individual will go in a different direction educationally, though each group will perform basic processes in order to get started. First, the students will go through the thinking process: finding out what everyone in the group knows, determining others that could give additional information for help, and figuring out what they need the most help with. As a group they will brainstorm ideas, create sketches (for example a parts list), and determine from the criteria sheet what they have to work with and what they have to do. The students may then reach the point where they will ask the question: How should we accomplish the competition? That is when the group must come together to create a common goal, determine tasks for each person, and begin working on the competition. Specific stages that the students may go through can be summarized by Williams (2000, p. 3):

1. **Evaluation**—What is the challenge (competition), what must the student do, what are the criteria?
2. **Communication**—What do the students know, where can they get the information, and how can they share ideas?
3. **Modeling**—What has been previously done?
4. **Generating Ideas**—Brainstorm, create sketches, gather resources.
5. **Research and Investigation**—Use the Internet, talk to others, experiment with ideas.
6. **Producing**—Make the product, draw the plans, write answers, and determine solutions.
7. **Documenting**—How did they get their final product or idea?

Because each challenge that is given to the students will require a specific thought process for the competition, not all of the above processes may be used or each group may use the processes in a different order.

STANDARDS FOR TECHNOLOGICAL LITERACY

When planning a competition, it is important to create a direct connection to the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). In fact, any competition that the students are engaging in should be directly related to the *Standards.* Depending on the *Standards* that the teacher is trying to accomplish, the teacher can design the competition to address the standard relatively easily. For example, consider that a technology class has been challenged to design a new bridge to replace an older damaged bridge. First, the students will need to look at building the bridge without altering the natural surroundings. Once the students study how to avoid disturbing the natural surroundings, they will seek alternative methods to complete the competition, all of which relate to Standard 13—Assess the Impact of Products and Systems. Standard 13 relates to how products are assessed in society, in this case, the impact a new bridge will have on the city or local area.

Such a competition is also related to Standard 20—Construction Technologies, for which several criteria must be considered. For example, the bridge span, the weight load, and the width all must be considered. In addition, other requirements should be considered, such as the materials to use and the processes that must come together to create a safe, sound, and usable bridge. In this case, as the competition is completed, benchmarks, such as structures, systems, foundations, and construction designs, are all related to Standard 20—Construction Technologies.

In addition, other components of the competition would also relate to Standard 20—Construction Technologies. The students need to collect information to determine the best materials to use and then draw conclusions about the materials used in the design of the bridge. With this information at hand, students can evaluate what steps to take, analyze the risks, and analyze trade-offs to design a safe bridge.

Once the students have researched the impacts, materials, and processes to be used in the bridge design, specific procedures must be considered. For example, the following questions need to be answered:

- What are the specific skills to assemble the bridge, such as welding, bolts, prefabricated components, etc.?
- What are the costs going to be?
- How will the design fit the actual function of the bridge?
- How will the bridge be maintained?
- What will it take for the bridge to maintain its beauty and structural stability for many years?

As such questions are researched and studied, it becomes evident that many benchmarks in Standard 20—Construction Technologies are being met by including the competition in the technology education classroom.

SUMMARY

Educating students does not solely come from a traditional classroom setting. Consequently, student competitions are a means to creatively engage the critical thinking of students. With competitions as an instructional strategy, students are allowed to break from the conventional thought process and expand their creativity by exploring the unknown, allowing students to reach higher educational goals through their ideas and knowledge. In addition, students will gain pride and self-worth by watching their ideas come to life. The students will learn new technological information about the curriculum, as well as meet both state and national standards in technology education. Depending on whether the competition is a classroom activity or an extra-curricular event, the rewards could be trophies for their school, trophies for individuals, or educational scholarships. Regardless of the physical reward and the educational learning, the students will gain pride in their work and have a positive experience to look back on, one that no one can take away.

Student competitions are far more than the large state or national competitions. Clearly, student competitions, from small to large competitions, can occur every day in any classroom. Allowing the students to design, research, build, and assess the problems stated in a competition encourages them to be creative and to test their ideas. Challenge your students to think outside the conventional box by including competitions in your technology education classroom.

DISCUSSION QUESTIONS

1. What are some of the major considerations when incorporating competitions into the technology education classroom?
2. What would be three advantages and three disadvantages of using competitions in the technology education classroom?
3. How can a technology teacher motivate all students to compete in a classroom competition?
4. How do competitions as an instructional strategy address the *Standards*?

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Using Community Experiences in Technology Education

Chapter 13

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INTRODUCTION

It is critical that the classroom be expanded to include many aspects of the community in the technology education discipline. Some of the methods of involving the community in a technology education class will take place in the school while others will be outside of the school. In either case, it is important to utilize the community resources appropriately in order to gain the most benefit for all involved. As noted in the International Technology Education Association's (2000) *Standards for Technological Literacy: Content for the Study of Technology,* "Community leaders also need to help youth in their communities by supporting quality technology programs" (p. 203).

PURPOSE

The purpose of this chapter is to define, describe, and identify how to maximize the use of community experiences in the technology education classroom. Again, the ITEA (2000) notes, "Ideally, other members of the community can also become knowledgeable about the study of technology and the importance of standards as a means to bring about reform in education and promote technological literacy" (p. 203). This chapter will explain how to help the members of the community to become knowledgeable about your program so that they can be a better resource for you and the students. The focus will be on the process of using community experiences and will include several examples of ways to use the community as an instructional strategy.

DEFINITION OF INSTRUCTIONAL STRATEGY

The utilization of community experiences provides students with opportunities to develop a greater understanding of the technological world within which we live. The ability for the students to see and discuss technological advances helps to give them a better understanding of how technology affects society. Such community activities will help to enhance the technological literacy of the students through first-hand experiences. As Boethel (2000) notes, "Service learning and entrepreneurial education place student learning in a community context. Students learn academic, work, and citizenship skills in real world settings" (p. 2).

As a teacher begins the planning for community experiences, many issues need to be examined. Boethel (2000) identifies the following issues:

Changes in Curriculum Planning and Instruction. For community-based learning to be successful, it must be integrated into the ongoing curriculum.

Assuring Academic Credit. Some community-based learning activities can be incorporated into existing courses with relative ease. Others require special arrangements.

Safety. With security a growing concern on school campuses, many schools have taken steps to limit outside access. While safety must be an overriding consideration, security policies in many cases also have served to intimidate parents and community members, discouraging them from visiting the school.

Transportation. Access issues also include concerns about transportation, primarily for students to get to community sites, but also for parents and community members to get to the school.

Scheduling. For some projects, class schedules may need to be adopted to support service learning or entrepreneurial activities. It's difficult to build a house in 50-minute increments.

COMPONENTS OF THE INSTRUCTIONAL STRATEGY

The utilization of community experiences help to enhance the learning of the students and allows them to see the abilities of the technological world in action. The utilization of the community and community experts is essential to the preparation of understanding how technological systems are designed and the impacts they have on society and the environment. Three types of experiences fall within this instructional strategy. The categories are (1) supplemental course in-school experiences, (2) supplemental course field experiences, and (3) a complete course utilizing community experiences. Listed in **Figure 13-1. Examples of Community Experiences**

Figure 13-1. Examples of Community Experiences.

In-School Experiences	Field Experiences	Complete Course Experiences
Bringing in the expert	Local tours	Internship
Professional organizations	Community events (fairs, open houses)	Part-time job
Local, state, and/or national organizations	Personal employment	School-to-work programs
School experts	Job shadowing	Partnerships
Organization literature (books, literature, videos, etc.)	Conferences	Volunteer opportunities

are several examples for each of these categories that can be used in a technology education class. It will be up to the individual instructors and the experience and interest of the student to determine which have the greatest potential of working in their individual learning environment. Some overlap occurs, but these will be discussed as different applications of the instructional strategy of community experiences.

APPLICATION OF INSTRUCTIONAL STRATEGY

Any one of the experiences listed in **Figure 13-1. Examples of Community Experiences** could be the subject of an entire chapter. This chapter is designed to be a guide to utilizing the instructional strategy. An example will be provided for each of the three broad categories of experiences. Again, each will be a conceptual example and cannot possibly answer all of the questions. By reviewing the examples, technology teachers should be able to apply the strategy in their classroom.

Not only does this type of instructional strategy offer a variety of community experiences, but as Edwards (2001) notes, "The first step was to stop assuming my community experience would be similar to that of my students, and to begin asking students to define and seek their own relevant goals" (p. 39). Another aspect of this instructional strategy involves the area of service learning. According to Edwards (2001), "Service learning differs from volunteer work in one major way: it includes the element of reflection. Projects are organized to meet the needs of the community, then integrated into the curriculum" (p. 40).

SUPPLEMENT TO COURSE CURRICULUM

This section will discuss two of the community experiences. They are both supplements to the current course curriculum designed to enhance the current course content/instruction taking place. With supplemental types of experiences, two variations, in-school experiences and field experiences, occur.

In-School Experiences

A variety of in-school experiences are noted in **Figure 13-1. Examples of Community Experiences.** The example that will be explained is bringing in a community expert. This is a common activity, but like all common activities may not be currently designed and used to the fullest potential. This discussion is designed to be a starting point for the use of this instructional strategy. By reviewing the example, you will perhaps develop ideas about how to improve your current practices and gain ideas for activities you have not tried in the past. The key is to remember that these activities must match the curriculum and be used to enhance the standard method of delivering course content.

Bringing in the Expert

1. When bringing in an expert, you should define the goal of the speaker. Students should be provided with an educational experience that correlates with the course content they are studying.
2. When you contact the expert identify your name and position, your school, and the purpose for the call. When contacting experts, ask them if they could come into your classroom and give a presentation on their area of expertise. They may be interested or not. It will be important to have information ready for them, such as the time of day, length of presentation time, and things you believe would be the best to cover, as well as any other requirements you may have.
3. Tell experts what is required while attending your classroom. Because most schools require a visitor's pass, be sure to give speakers the information needed to obtain one and directions to the area you would like them to go.
4. Coordinate the best time for each speaker and the class. Bringing someone to your class will limit the time of day that best works for the expert.

5. Prepare the students for the speakers in order to develop a basic understanding of the area of expertise. The area should correspond to the curriculum being used. The students should understand what the type of business each expert is in and its impacts on the technological society in which we live. Have the students brainstorm some questions to ask. Each student or group should have questions prepared. Because many questions may arise during the presentation, students should be encouraged to ask questions as they come to mind. Let the students know the format of the presentation prior to each speaker's arrival (and communicate that with the speaker).
6. As the instructor, you should prepare the students, by providing information about the speaker and about the uniqueness of the area.
7. Follow up with students, and allow them time for discussion.
8. Follow up with the experts, thank them for their time and effort, and ask if anything could be done to improve their visit next time.

Field Experiences

The second supplemental experiences are field experiences. These can and should be much more that just a tour. The tour will be discussed as a model, but many other community experience are listed in **Figure 13-1. Examples of Community Experiences.**

Going on a Tour

1. When going on a tour, define the goal of the tour. Students should be provided with an educational experience that correlates with the subject area they are studying.
2. When you contact the company or organization identify your name and title, your school, and the purpose for the call. When making contact with the company you would like to visit, ask company personnel if they normally give tours to groups of students. If so, find out what the tour includes. Depending on the size of the company, you may have access to literature that you can review to make sure the tour covers the areas of the curriculum that will enhance learning. If tours are not normally given and yet the company personnel are willing to give a tour to the students, ask if a pre-tour would be possible for the instructor to identify the areas that correlate with the curriculum. Because not all companies will give tours to student groups, try to get information about the company and leave your

name with contact information for them in case the policies or personnel change.

3. Identify what the safety requirements are for the group involved with the tour.
4. Coordinate the best time for them and your class. Because they are providing the tour, it is important to be flexible in your schedule. This may mean that the area being covered in the tour could have already been discussed in your curriculum or you may not have progressed to that area yet. It is important to prepare the students before leaving on the tour so that they can actively participate in the tour.
5. Prepare the students for the tour outside of the curriculum. The students should understand how the type of business they will visit impacts the technological society in which we live. Have the students brainstorm some questions to ask while on tour. Each student or group should have questions prepared. Because many questions may arise during the tour, students should be encouraged to ask questions as they come to mind. The format for questions may vary depending on the company or the environmental conditions of the tour.
6. The instructor should prepare the students for all the aspects of the tour. Because student conduct is important while visiting, stress the importance of proper behavior and respect. Tour participants should follow the guidelines set by the company giving the tour to ensure a safe tour.
7. Follow up with the students when you return to the classroom. Review the tour, the impacts the company has on our society and the environment, and the ways this information could be used to help develop into career opportunities for the students. Discuss some of the positive and negative things that they saw while on the tour.
8. Follow up with the company by sending a thank-you card or e-mail. Be creative and involve the students in the follow-up. Talk with the contact person to see if you may continue to take tours in the future and whether anything could be done to help facilitate tours in the future.

COMPLETE COURSE CURRICULUM

A different method of utilizing community experiences is to have the entire course curriculum based on a community experience. Some of the most common examples are internships and school-to-work programs. These can be great experiences for some students, but like all education, they need to be planned and monitored during the experiences. An instructional strategy designed as a complete course curriculum is a business internship. This will be discussed in detail to provide an example of how a technology teacher might utilize this strategy in the school.

Internships provide many benefits to the student, the company, and the school. The student will benefit by learning technical knowledge of a career, career skills, and many "life" lessons as a result of holding a job. The company will benefit by meeting a new, young employee who may bring new ideas to the position and by taking advantages of a low-risk opportunity to evaluate a potential lifetime employee. Finally, the school will benefit by establishing a new contact in business, gleaning current knowledge from the business world, and in most cases gaining a future supporter of the program.

It is critical that the internship be designed as an educational experience. *All parties must understand and agree* to that concept before starting the internship. This increases the chance that the student has a positive learning experience. Instead of being placed on an assembly line for the semester, the student should be rotated through a variety of positions in the organization.

Some of the steps in establishing an internship may include the following:

1. The teacher establishes the number of hours that must be worked for credit for a course.
2. The student makes application for a position with an industry/company as though he/she were applying for a regular job. If the industry/company is interested in employing the student according to the internship conditions, an Internship Application should be completed by the student before the interview. Salary is determined during the interview by mutual agreement of the industry/company and the intern.
3. Before a student begins an internship, if the industry/company agrees to employ the student as an intern, an Internship Acceptance Form is signed by the supervisor and/or another person of authority in the industry/company.
4. The teacher and/or other school personnel should make regular visits to the industry/company.

5. A complete file should be kept on each student who has completed an internship. This file should contain copies of the Internship Application Form, Internship Acceptance Form, the Internship Report for each week worked, and a final term paper by the intern involving a critical review of his/her form signed by the employer.

A variety of management tools can be used to track and document the internship. By developing standard forms, the consistency of the internship can be increased. One of the forms that should be used is a summary of weekly experiences. The form might include the following items:

Weekly Internship Report

1. Date
2. Name of intern
3. Job title
4. Name of company
5. Address of company
6. Name of company supervisor
7. Phone number of supervisor
8. Summary of week's work experience
9. Hours worked
10. Items learned
11. Positive experiences of the week
12. Negative experiences of the week

At the end of the internship, it is important to bring some type of closure to the experience. One method of accomplishing this is the completion of a final report by the intern.

Final Internship Report

The purpose of this report is to provide a means for closure and summarization of the internship experience. Provide an additional means for evaluation of the experience as it relates to the intern, the agency/company, the school, and future employment. It is expected that reports will vary widely from one intern to another. However, each report should contain at least the following elements:

Introduction

Use this section to introduce the reader to your internship position. You might include such items as the following:

1. How the position was obtained.
2. How it relates to your immediate and future goals.
3. Information about the employer, i.e., what makes the agency/company special or unique.
4. What special equipment the agency/company has.
5. What particular talents or experiences the supervisors have that has made the experience particularly valuable.

Body

The main portion of the report is the actual summary of the experiences encountered. This may include such things as the following:

1. Discussion of general job progression over internship period.
2. Highlights of internship (incidents which stand out as unusual).
3. Charts, tables, or lists enumerating the skills learned and the degree of efficiency.
4. Tables or charts showing tools and machines used and/or observed.
5. Photographs or accompanying slides which tell a story about some phase of the internship, and which may later be used in the intern's own classroom. (Ask your supervisor for permission before taking pictures.)
6. Where feasible, samples of work may be included. This is particularly helpful for those working in the graphics industries. If work samples are included, their significance to the experience should be clearly explained.

Conclusions and Evaluation

In this section include an honest evaluation of the following:

1. The experience
2. The station
3. The agency/company supervision
4. The school supervision

Take this opportunity to suggest how the employer can improve the experience (e.g., more frequent rotation), how the school might improve its service (e.g., more or fewer visitations, better timing), and how future interns might do a better job for the agency/company and/or gain more for themselves.

RELATIONSHIP TO *STANDARDS FOR TECHNOLOGICAL LITERACY*

While developing a plan for bringing an expert to the classroom as part of a teaching strategy, remember that it is designed to address the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). The following scenario is an example of how one can enhance curriculum while utilizing the *Standards.* As noted earlier in the chapter, using the community experiences should enhance the curriculum. The following is an example of using the community experiences and their relationship to technological standards in a high school residential construction class. Class size, physical space, length of class, and research availability are some things that may limit some of these strategies; however, these concepts can be manipulated to fit your needs. The elements of these strategies are based on a structure design that is typical for the area in which the students currently live. The students should develop a sketch of a structure that they would like to live in. This will be the base for the development of the students learning about the technological systems involved in residential structures. This sketch will be embellished upon and a model structure will be constructed of the final sketch/drawing. The student will have a portfolio of all information obtained within the completed model. Invite a local contractor in to discuss the various responsibilities of being a contractor. The contractor could look at sketches or models and discuss potential problems with the design or talk about the various building processes to complete a project. This would be a good opportunity to have the speaker address employee issues (job application processes, expectations of new employees, and other career issues).

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

Benchmark Topics Grades 9–12 Addressed:

1. Structures are constructed using a variety of processes and procedures.
2. The design of structures includes a number of requirements.

3. Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.
4. Structures can include prefabricated materials.

Introduce the students to the systems involved in the development of a residential structure. The students should be provided with the resources to locate the required information and develop a chart/diagram that shows the relationship of other technological areas to residential construction, as well as the social and environmental systems involved.

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

Benchmark Topics Grades 9–12 Addressed:

1. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.
2. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.
3. Management is the process of planning, organizing, and controlling work.

Once the relationship of residential construction is established, the resources required for the construction need to be discussed. Residential structures vary greatly from one to another and region to region; therefore, the students need to understand a variety of techniques that are used to help them understand the resources involved. The students can be assigned a certain region to investigate common resources used in a particular region. This may include regions of the world or regions of North America or the resources used within a student's own region. The items students should investigate are availability, cost, desirability, and waste. The students may use a chart to help evaluate the information gathered.

Standard 9: Students will develop an understanding of engineering design.

Benchmark Topics Grades 9–12 Addressed:

1. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
2. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.

These may be broken down to the stages of the development of the structure: foundation, sub-grade structure, floors, and walls, continuing to the completion of the structure. Invite a local building official to present information to the class on building codes and inspections required related to various stages of construction.

Construction management is critical to provide a desired outcome of all of those involved. An activity that will help students understand the complexity of management may be to look for schools that provide these degrees and ask students to develop a list of schools and the requirements for attending those schools to see whether they will or can fulfill the requirements.

Many aspects of the environment are affected by the construction of new structures. Of those, the students may investigate the state requirements for rural water and septic systems. Have students select a property that will require a well and septic system to be designed. Then ask students to write a letter of inquiry to the county to obtain the information for design criteria. Other aspects of the environment may include population and its effects, watershed, visual impacts, and structure design considerations.

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

Benchmark Topics Grades 9–12 Addressed:

1. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing and recycling.
2. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.

SUMMARY

Community involvement is an instructional strategy that can greatly enhance the existing curriculum and help address many of the *Standards*. Similar to all instructional strategies, community involvement takes good planning and organization to implement in the classroom. As Edwards (2001) notes, "Bringing in an occasional speaker or visiting an exhibit at a city museum only starts the process of bridging the gap of relevance. Connecting the school and the community means listening to the community in which the school is situated, so that the individual voices of those students and of that school can be the foundation of the education those students receive" (p. 44). Several community experiences are available for all schools; identifying, educating, and using the experiences is the difficult part. This chapter provides a couple of examples as a place to begin using this instructional strategy. These and many more great experiences are waiting for the students.

DISCUSSION QUESTIONS

1. What types of community experiences would match your curriculum?
2. What resources are in your community and how do they match the current curriculum?
3. What areas of expertise would complement the expertise already in the school?

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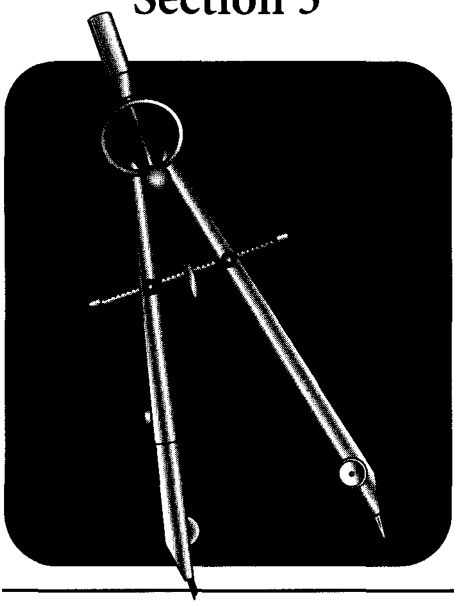
Section 3



ASSESSMENT & SUMMARY

Section 3 is designed to provide closure to the instructional strategies cycle. When an instructional strategy has been selected, it is critical that some form of assessment takes place as to its success. Chapter Fourteen, Assessment of Instructional Strategies, introduces the definitions, importance, and methods used to assess the success of different instructional strategies. Chapter Fifteen, Summary and Reflections, summarizes the total yearbook and reflects on the overall relationship between the success of technology education and the selection of appropriate instructional strategies.

Assessment of Instructional Strategies

Chapter 14

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INTRODUCTION

Because teachers have worked with students in classroom settings for thousands of years, one might think that by now educators would have identified the optimal approaches to teaching. Yet as DeMiranda and Folkestad (2000) point out, all too often, "the teacher lectures and students listen. There is little discussion and few opportunities for students to contribute their own feelings, ideas, or concerns during the course of instruction" (p. 7). In a previous era, this might have been acceptable practice, but in light of recent research on how the human brain learns, this approach falls far short of optimal instruction. DeMiranda and Folkestad continue, though, to offer us hope through "brainfriendly" instructional strategies such as collaborative learning, socially-distributed expertise, design/engineering, and product-based learning (pp. 9–10). Yet it has been said that to a person with a hammer, everything looks like a nail; educators must not get caught up in the trap of latching onto a methodology, even a research-supported methodology, and using it exclusively. Teachers must approach classroom instruction as a technologist approaches a problem, with a variety of tools, and they must select the appropriate instructional tool to align with the concept to be taught. Dugger (2001) refers to this alignment as "articulation" (p. 515) and recommends that articulation of instructional approaches be done in a K–12 education setting in a systematic way that aligns curriculum with both optimal and developmentally appropriate instruction. This chapter will provide suggestions for aligning instructional strategies with the technology concepts to be taught through the process of assessing instructional practice.

PURPOSE

Assessment in educational systems occurs in a variety of forms and for a variety of purposes, but ultimately can be summed up as monitoring progress and serving simultaneously as a catalyst and compass for change (both of the student and system). However, if assessment is to effectively serve in these roles, it must be purposeful, manageable, and embedded within the system.

CIA (Curriculum, Instruction, and Assessment): A Relational System

The process of teaching about technology is still often accomplished through the use of an educational system where curriculum serves as input, instruction becomes the process, and assessment occurs in the form of a required product (output). In many cases, teaching is also an interactive process, and this same instructional system is repeatedly applied to many groups of students. Too often, however, educators overlook or underuse the fourth element in a traditional systems model—feedback. Feedback is key to moving an interactive instructional system in a direction of continuous improvement. It must be conceded that all aspects of the system (input, process, output, and feedback) impact the final outcome or, in the case of an educational system, the learning that takes place. However, since curricula and assessments are often influenced or provided by school districts, states, or provinces, the variables that the teacher most frequently controls are instruction and feedback. This chapter therefore, will further focus on methods of instructional assessment, or the use of feedback, to evaluate and improve classroom instruction and student achievement.

Focusing on Best Practice in Instruction

The most effective instruction in technology education (or any other discipline) is referred to as "best practice," which could be described as the characteristics of outstanding teaching that are highly valued within the profession (Zemelman, Daniels, and Hyde, 1998). Frederiksen, Sipusic, Sherin, and Wolfe (1998) further contend that to be highly valued by a profession, best practices must be based on nationally accepted work from that profession, such as national standards. Those standards, and in this case the *Standards for Technological Literacy, Content for the Study of Technology* (ITEA, 2000), referred to as *Standards*, provide the criteria by which instruction can be judged as being effective. While this seems a reasonable approach, it is important to realize that "what is highly valued by the profession" is a moving target: as standards and national curriculum recommendations change, instruction must parallel that change. Therefore, best practice in technology education is constantly changing and can be defined only within the context of a particular period of time. While the unveiling of the *Standards* begins a new chapter in technology education instruction, in some ways it is better viewed as a break from tradition rather than a continued evolution. In terms of effective classroom instruction, the *Standards* will likely require teachers to modify current methodology or devise new strategies altogether (DeMiranda & Folkestad, 2000), and the *Standards* must become the criteria by which the effectiveness of instruction will be judged.

The previous chapters in this yearbook outline many instructional strategies, each of which has the potential for varying levels of success. It is, therefore, essential to select the optimum instructional strategies to deliver each major technology concept. Although experience in teaching will allow teachers to view instructional variables (e.g., student prior knowledge, student learning styles, laboratory equipment) and select an appropriate instructional strategy, it is necessary to use some form of assessment to verify the optimization of strategies. In addition to the task of aligning content to instructional strategies, we are constantly reminded that each student brings a unique set of cognitive constructs to a learning situation, and each has a preferred learning style. Thus, while teachers must select an overall instructional approach to align with a concept to be taught, they must also remain flexible, adjusting instruction to meet the individual needs of students to the extent that can be managed.

ASSESSMENT OF INSTRUCTIONAL STRATEGIES

Though teachers can exert influence over many parts of the educational system, the variable that they have most control over is instruction. However, while teachers may frequently employ a variety of instructional strategies, too often the instruction selection criteria is not at all based on an assessment of that strategy's application or value to the concepts being taught. Further, if post-instructional assessment is used, it is too often used to critique the work of students rather than the work of the teacher. Assessing the instructional approach is a critical place for the teacher to begin.

The Tools of Teaching: A Variety of Instructional Approaches

Evaluating the success of instruction is of little value unless other instructional options are available as alternatives to the first approach. Two additional factors make it essential to develop a variety of instructional methodologies to have in any teacher's "tool kit": the continuing evolution of the brain and the evolution of curriculum.

Brain Evolution

Through the work of Dr. Marian Diamond (1988) and others, we know that the human brain is physiologically constructed through the experiences it has in early development. Thus, over time, as technology such as electronic media and other forces modify how information is presented to the developing brain, the human brain is being "hard wired" to efficiently absorb information in different ways than past generations. In that sense, the student is constantly changing, and the same instruction that has been successful for a period of time may cease to be successful when enough student change has occurred. Therefore, teachers must constantly be devising new instructional approaches that parallel the generational changes in learning preferences.

Evolution of Curriculum

With the arrival of the *Standards,* the evolution of technology education curriculum continues—but not only with new content to be learned. As an example, the *Standards* promote teaching students how to perform technology design, which requires a much different instructional approach than teaching skill development in an industrial arts program. The *Standards* also promote a K–12 approach to educating students, as opposed to the prevailing American model of 6–12 or 7–12 technology education programs—and elementary students in the concrete developmental stages of learning will require different instructional approaches than secondary students who are capable of much greater abstractions. Thus, instructional methodology must evolve to reflect changes in curriculum, and assessment of those methodologies must be ongoing as well.

Matching Instructional Strategies with Learners

For the sake of efficiency, most instructors will match an instructional strategy to a concept to be learned, and use that strategy with the entire class. Approaches such as those used in modular technology education laboratories may further restrict the variety of instructional strategies used. Yet, Manning (1995) asserts that "diversity is the hallmark characteristic of young adolescents" and that we have a history of "teaching without regard to an individual young adolescent's cognitive development" (p. 98). Chapter 2 in this yearbook on student diversity provides suggestions for addressing the diverse needs of students which can be used in combination with analysis of individual student assessment results to provide information on which students may need an individualized learning approach. Too often educators assume to have done their part if most of the students have learned a concept, disavowing responsibility for all students' successful learning. Conferencing with students, parents, and other teachers will often provide insight into alternative strategies for working successfully with a particular student. And for students with a history of difficulty in school, the counseling department may have additional assessment data (e.g., the Cognitive Abilities Test by Riverside Co.) that will reveal clues about a student's learning preferences. While many of the same approaches for evaluating the effectiveness of teaching strategies with a class can be successfully used with individual students, it is the commitment to be willing to use them for an individual student that is the greatest obstacle to overcome.

Appropriate Methods of Assessing Instructional Strategies

Assessment of instructional strategies may be placed along a continuum from informal (self-assessment) to formal (supervisory assessment). However, one cannot assume that less formal assessments are less valuable. In fact, as in most assessment plans, effective assessments will be frequent, embedded, and varied. Each of the following types of assessment has a specific advantage in contributing to improved instruction and should be considered as part of a comprehensive instructional assessment plan.

Teacher self-reflection is the first step. The simplest method of assessing the success of instruction is to reflect on the lesson immediately afterward: Did the students seem engaged? Did the lesson and student experiences really focus on the concepts or outcomes to be achieved by students that, for example, are presented in the *Standards*? Did students seem to understand the concepts? What were the most frequently asked questions? What didn't work well? The answers to these and other questions provide immediate feedback that can be recorded as notes for future instruction on that topic. (Effective teachers will often write these notes in the Teacher's Manual, or on their lesson plans rather than relying on memory.) While most teachers could effectively use self-reflection without formal training, it may be helpful to provide a structure or format (similar to the video framework in the next paragraph) to guide the reflection, which could be developed as part of a school's performance review system, or a professional organization's addenda to standards.

As a second option for teacher reflection, Frederiksen, Sipusic, Sherin, & Wolfe (1998) have assembled a framework for video portfolio assessment of instruction. Teachers videotape lessons with students and while these authors strongly promote a peer group review of the instructional portfolio, their framework would directly relate to individual teachers reviewing their own instruction. Seven initial criteria, developed for their model in critiquing instruction, could easily be adapted to technology education (p. 230):

a) Actively engaging of students,
b) Adapting instruction to students' needs and interests,
c) Making the "big picture" clear,
d) Creating a climate of cooperativeness and helping,
e) Managing time well,
f) Monitoring how students are learning, and
g) Making [Technological Literacy] the goal of the class.

Because teachers in small schools or small districts are often isolated, they may find self-reflection the most accessible option for assessing instruction. Additional assistance in those cases can be found through on-line resources such as the International Technology Education Association (www.iteawww.org) or the North Central Regional Education Laboratory (www.ncrel.org) for information on standards or instructional best practice. However, just changing instruction to do something different is not necessarily synonymous with doing something better: additional information may well be needed to move in the right direction.

Ask the students. Effective teachers often have built-in feedback questions that can be asked of students throughout the learning experience that will allow the monitoring and adjusting of instruction midstream (a formative assessment model). These questions can focus both on cognition (whether or not material is being understood) and the affective domain (whether or not the instruction is motivational) (Fletcher, 1995). For additional information, students could be interviewed individually or in focus groups, or a formal question time (oral or written) could be set up to gather feedback from the entire class. Since in his work Fletcher found that adjustments in instruction occasionally resulted in teachers honoring student requests to cover less content, he also points out that critics of this approach may claim that teachers are perhaps "giving in" to student inactivity or lack of responsibility. However, successful instruction must be measured not by how much content is covered, but rather by what and how much students learn.

Assessing instruction through the lens of student success is another step in assessment. The ultimate proof of successful instruction lies in the demonstration of student learning; the focus of instruction must shift from "well presented concepts" to "well learned concepts." To that end, assessment of instruction must also include assessment of student learning. The lens of student assessment can provide much more specific information about the success of instruction.

When employing pencil and paper tests, item analysis should be done to determine which questions were most frequently missed. (Questions missed by more than 20% of the students would be a reasonable place to start—especially for critical concepts where student mastery is expected, while questions missed by 50% of the class would almost certainly indicate a teaching problem rather than a learner problem [Guskey, 2000].) If the frequently missed questions have been soundly constructed (questions are not biased, misleading, or developmentally inappropriate) and are significant (focus on the concepts critical to the learning outcomes), then the instructional approach should be adjusted the next time the concept is taught to place greater emphasis on the concept or allow students to engage more directly with the concept.

Since many variables affect an individual student's learning, it is much more valid to use this approach with large numbers of students (whole classes or multiple classes); over time, the results of a variety of instructional strategies could be compared and objective decisions made about the relative success of each. Keep in mind that instructional strategies cannot be viewed as "one size fits all"; in fact, a successful strategy for one concept may not work equally well for others. Therefore, it is essential to associate the concept being addressed with the instructional strategies used when doing the item analysis. Teachers too often make the assumption that students have failed to adequately prepare themselves when test results are poor when in reality the instructional approach has a significant bearing on that student's achievement.

When using authentic assessments with students, thematic analysis will replace the item analysis approach just discussed. Since authentic assessments tend to be more holistic and open-ended, the instructor must analyze student performance for themes that appear in the work of many students—critical concepts that appear to be frequently missing or misunderstood. Zemelman, Daniels, and Hyde (1998) provide a list of authentic types of assessments that can be used to gather evidence of student learning including: "Kid watching, observational notes, interviews, questionnaires, checklists, student artifacts and work samples, performance assessment, student self-evaluation, evaluation conferences [and] portfolios" (p. 245). A scoring or evaluation matrix could be used with any of these types of authentic assessments to plot critical or essential concepts across a class when identifying themes that need to be addressed differently.

Throughout both of these approaches, it is important to also search for topics that students have successfully learned, thus providing evidence that the instructional strategies used to deliver those concepts have been successful and should be continued.

Peer Coaching/Peer Collaboration

Each teacher has developed a variety of approaches or techniques in their instructional "bag of tricks." While some of them may be dependent on teaching style or background, many of those techniques are easily transferred to other teachers. One significant problem, however, is having opportunity or access to observe other teachers. In fact, the Third International Math and Science Study (TIMSS) revealed that close to 80% of all Minnesota math and science teachers have never observed another colleague teaching (SciMathMN, 1998)—unlikely to be much different for other states or other disciplines, including technology education.

The concept of peer coaching, which breaks down the isolation of teaching, is an agreement or commitment between two teachers to observe each other teach and dialog about what they observed. This collaborative effort not only brings two sets of experiences and strategies to the table for discussion, but it has a number of advantages over observations by administrators:

- Because the observed teacher and students are likely to feel less stress, the event is therefore more likely to be "normal" or "typical" of daily instruction;
- The observing teacher may have greater content-specific knowledge than the typical administrator, which would provide insight into the

outcomes to be achieved (as well as the difficulty in delivering some of those concepts), and the observing teacher might even have had some of the same students in other classes; and

- Observations and discussions can occur much more frequently than would be typical of administrative observation schedules.

Peer coaching sessions should also be preceded by a planning meeting where the peers would outline the lesson plan, outcomes, and instructional approaches to be used: the observing teacher can be alerted to watch for particular strategies or student reactions. The observing teacher is not hindered by lesson delivery and is often able to observe details and student activity that escapes the regular teacher in the "heat of the moment." However, it is very helpful again to have the observing teacher take notes (or even videotape the activities) so that the post-lesson conference will be more complete. Of course, instructional strategies are an ideal topic for peer coaches to address, and the feedback from a professional colleague often proves invaluable. Once again, though, the criteria for judging quality instruction in technology education must be based on best practice related to the *Standards*.

On a more grand scale, peer coaching/collaboration could take on a global approach, such as the Minnesota Technology Education Association's plan to develop "E-mentors" to promote the concept of best practice in technology instruction (Minnesota Technology Education Association Summer Retreat; Personal Communication, June 25, 2001). Their plan is to create a list of technology education mentors that would be available to establish e-mail conversations with teachers in the field about effective instructional strategies for delivering the *Standards*.

Partnerships between teachers also can be focused on collaborative scoring of student work, such as the state scoring process in Maryland where "teachers reported that scoring had enhanced their understanding and application of the course outcomes and, by providing a valuable 'window into other classrooms,' had given them an expanded picture of students' capabilities" (Goldberg and Roswell, 2000, p. 258). In the Anoka-Hennepin School District (Coon Rapids, MN), 3,000 sample writing papers are collected annually at each of two grades and a district scoring team of thirty teachers is assembled and trained to score the papers for the district writing program. This process, like the Maryland example, not only serves to provide consistent and valuable feedback on student achievement, but fosters great discussion on what good writing looks like, establishes consistent standards for scoring, and provides an invaluable staff development opportunity for the scoring team. Similar approaches could be developed for individual school, district, or state technology education programs.

Teachers too seldom compare their students' work to the work of other teachers' students. Not only does the comparison provide more insight into the possible range of student performance, but within systems (such as a school or a district) it will also promote consistency of grading expectations and can become a first step in developing rubrics to guide future grading and inform future student work.

Quality Performance Appraisal Systems

Any educational system has an inherent need and obligation to optimize instruction as a means of improving the resulting student learning. And, since the educational system often takes on the role of employer, the system can exert additional leverage to improve instruction in the form of an Employee Performance Appraisal System. A quality appraisal system, such as those promoted by Danielson and McGreal (2000) and others, will include a critical analysis of instruction—including the gathering of evidence of successful student learning. Performance appraisal systems also have the advantage of impacting all staff—even those that would not have elected a continuous improvement effort on their own. Naugle, Naugle, and Naugle (2000) suggest Kirkpatrick's evaluation model (model is shown in the next paragraph) as a means of evaluating teacher performance, since that four-level model allows the assessment of teacher success based not just on student achievement at the knowledge level, but also at the student performance level. In addition, the Kirkpatrick model could be used with whole educational systems, which would provide feedback on the success of a department or system, rather than just individual teachers. This would encourage collaborative discussions between teachers on instructional strategies and could serve as a tool that would allow administrators to partner teachers or assign mentors to bolster the success of teachers whose students' performance was below par.

Kirkpatrick's model seems well matched to the goals of Technological Literacy, shedding light on the effectiveness of instruction from the micro level (classroom lesson) to the macro level (entire systems). It consists of the following four stages (pp. 136–141):

- The reaction level—getting student responses to the instructor, the materials and the experience;
- The learning level—knowledge acquired, skills improved, or attitudes changed;
- The behavioral level—transfer or application of learning;
- The results level—the acquired motivation of students to continue learning and the potential to carry their learning into the world beyond school.

It seems that this model or variations of it would address the core issues that we are concerned with: optimizing instruction to maximize student achievement and developing a K–12 system that would produce technologically literate citizens.

ASSESSMENT DESIGNED TO INFORM INSTRUCTION ON THE MACRO SCALE

It has often been touted that assessment drives curriculum and instruction; design assessments around critical outcomes and teachers will tend to teach toward the critical outcomes that are being tested. However, teachers often may find the relationship between assessment and instructional content more direct than the relationship between assessment and instructional methodology. Yet the relationship between assessment results and instructional methodology is so strong that "... the validity of a test cannot be evaluated apart from the kind of instruction it supports. . ." (Goldberg & Roswell, 2000, p. 259). Goldberg and Roswell go on to state that for teachers involved in scoring the Maryland State Assessments (designed around a performance-based approach to demonstrating student learning), "teachers said that prior to scoring their use of performance-based instructional activities and performance assessment was limited, but they predicted that following scoring their use of these approaches would be moderate to considerable" (p. 265). This finding has two immediate implications: first, teachers that are immersed in a critical review of student assessment data will be able to see the impact of instructional methodology on student achievement; and secondly, if those assessments are viewed as important (as in the case of the Maryland state-mandated tests), teachers will strive to modify their instructional methods to improve student achievement. Minnesota, Massachusetts (Bouvier & Corley, 1999), and other states are employing state-mandated tests to monitor the statewide progress and achievement on essential state standards, while using the test results as leverage to influence instruction. This use of assessment data not only provides compelling evidence that instructional methodology impacts achievement, but it also reveals the critical need for all teachers to be involved in the review of assessment data. In the Maryland example, it is likely that the teachers who were not recipients of the insights gained in scoring student work will also be less motivated to focus on performance-based instructional activities.

Statewide-mandated tests are often highly publicized and are designed as accountability measures to apply pressure to school systems. In turn, administrators apply pressure to teachers to improve scores. It is therefore also critical that technology educators and technology education associations become involved at the state level in the development, analysis, and revision of state assessments so that where appropriate, the assessments continue to focus on concepts essential to technology education, and in particular, the *Standards.*

The secondary implications of these findings are subtler. If a repository of exemplary assessments were readily available and used by teachers, they could drive instructional change in a positive direction. However, if teachers with little experience in assessment development continue to produce the same kind of assessments that they have used in the past, they will likely continue to instruct the same way and get the same results from students that they have in the past. Unfortunately, quality pre-designed technology education assessments that focus on the *Standards* are in limited supply at this time. (Sources such as *Teaching Technology: Middle School Strategies for Standards-based Instruction* [ITEA, 2000] are just beginning to appear and Phase III of the Technology for All Americans project—including *Assessment Standards for Technological Literacy*—just published in 2002.) Therefore, the majority of teachers initially will need to design appropriate assessments themselves. The following suggestions are from draft work of the *Assessment Standards for Technological Literacy;* though they may change before that document is published, they nonetheless provide reasonable direction for developing assessments that would begin to improve instructional practice:

- The assessment of student learning will be consistent with *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000), which specifies outcomes for technological literacy—the ability to use, manage, assess, and understand technology.

- The assessment of student learning should have clarity of purpose; specify whether the measures are for formative, summative, or evaluative ends; and should be explicitly matched to the intended purpose.
- The assessment tools and processes will be applied in a continuous and systematic way, will be derived from accepted assessment principle, and will address issues of measuring student performance, test management, and test security.
- The assessment of student learning will reflect the practical, real-world nature of technology, using a variety of contextualized, performance-based, and holistic approaches.
- School personnel, policy makers, and the general public will understand, value, and use the results of student assessments to make decisions and develop action plans to improve students' technological capability (ITEA, 2001, pp. 1–7).

SUMMARY

Effective teaching is dependent on developing a variety of instructional strategies and matching the correct strategy to the concepts being learned. Assessment of the effectiveness of those strategies is essential at both the classroom and whole system levels and must be a continuous process employing self-reflection, feedback from students, analysis of student achievement, peer interaction, and system evaluation. As we embrace the challenge of developing technological literacy in all students, it will require us to continually reevaluate our instructional methodologies and embark on a model of continuous improvement in preparing students for a continually changing technological world.

DISCUSSION QUESTIONS

1. What does good technology teaching look like? What is best practice in teaching technology?
2. How does one identify the optimum instructional options in approaching specific subject matter?
3. How can teaching become more effective? What is an effective model for continuous improvement?

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Summary and Reflections

Chapter 15

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Technology Education as a discipline continues to move into the mainstream of education. This has been a result of advancing the profession/ discipline to a general education approach and incorporating a variety of instructional strategies instead of relying on the project method of the past. As Gilberti (2001) noted in the *2001 CTTE Yearbook*, teaching a variety of concepts "can be fostered by utilizing the best lecture based and laboratory experiences common to technology educators including the use of case studies; interdisciplinary approaches; modeling, gaming, and simulation; the project method; research and experimentation" (p. 233). These and several other instructional strategies have been addressed in this yearbook.

SUMMARY

Throughout this yearbook, the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) has been addressed with one main question in mind: how do professionals in the discipline teach the content area of technology education using a variety of instructional strategies? The field has advanced a long way from the teaching of manual arts and industrial arts. The progress must continue for the discipline to truly become an integral part of general education.

This yearbook began with a discussion about learning theory and student needs in Section one. According to Valesey in Chapter 3, "Defining your personal philosophy for technology education enhances your curricular and instructional decisions. Articulating what is real, what you believe to be true, and what you value positions your philosophy as a foundation for teaching and learning. Using your philosophy strengthens the connections between what you know, do, and believe as it is conveyed to students in your classroom." This section is designed to provide an understanding of the role that student needs and teacher philosophy play in the selection of instructional strategies.

Section two of the yearbook defined and demonstrated how to teach technology education using a variety of instructional strategies. This section is especially important because technology education has moved beyond the project method of the last century. These strategies varied from student competitions to out-of-school experiences to interdisciplinary approaches. While the exact application of these instructional strategies will vary from class to class, the use of various instructional strategies allow for meeting the needs of a variety of students with diverse learning needs.

Not only is it important to teach different content based on the *Standards*, technology education must also teach with different instructional strategies. As Hoepfl noted in Chapter 4, "The first premise of teaching for understanding is that we must identify what, and how, students think about the topic being studied and then build upon that conceptual base." McAlister continues the idea in Chapter 6, "Humans continue to mold and shape their worlds through the use of technology, and in turn technology has changed many lives. It is only fitting that students gain a better understanding of interrelationships between the human-altered world and the cultures and societies that molded them. In what better place should this occur than in our schools as a part of every child's formal education." Using the social/cultural instructional strategy, technology education classrooms provide students with the opportunity to examine these relationships.

Technology is also providing new tools to deliver the content of technology education. As Roberts and Hopewell note in Chapter 10, "Web-based instruction provides opportunities to deliver the entire content of a course (Web-based instruction) or to supplement traditionally delivered content (Web-enhanced instruction)." In addition to the technology outside the classroom, there are changes in the classroom. As Rodriguez and Schwaller note in Chapter 11, "First, modular technology classrooms and environments work well if used as one of many instructional strategies in the classroom. Modular systems should also be considered an integrated system, not the one and only way to teach technology education. In addition, teachers placed in modular technology classrooms need to be trained and prepared correctly in order to be successful in this type of environment." This highlights the need for teachers to continue to learn about emerging instructional strategies.

Finally, Section three discusses the importance of assessment and final thoughts on implementation of this yearbook into the classroom. As Lindstrom notes in Chapter 14, "Yet it has been said that to a person with a hammer, everything looks like a nail; educators must not get caught up in the trap of latching onto a methodology, even a research-supported methodology, and using it exclusively. Teachers must approach classroom instruction as a technologist approaches a problem, with a variety of tools, and they must select the appropriate instructional tool to align with the concept to be taught." Without assessing the activities that take place in the classroom, the teacher does not have an indication of the effectiveness of the instructional strategies, delivery methods, or the instructor.

REFLECTIONS

It is impossible to provide all of the material needed to cover the topic of instructional strategies for technology education. Thus, this yearbook only provides a guide for selecting instructional strategies. It should be part of the overall "best practice" by the technology teacher. Just as each author connected instructional strategies with the *Standards,* it is important that the technology teacher continue to connect the *Standards* to the content taught through various instructional strategies. As one looks over this entire yearbook on instructional strategies, several reflections can be made for teachers today and in the future.

1. Over the past several years, the research on instructional strategies has increased. Instructional strategies are now considered a critical component to the success of technology education.
2. Technology content to teach based on the *Standards,* but success also comes from a solid foundation in the study of contemporary instructional strategies.
3. The study of learning theory and brain research has become critical to the success of a technology teacher. Without knowing how students learn, especially in different environments and diverse learning styles, it would be difficult to select appropriate instructional strategies to enhance the technology education classroom.

4. There are many excellent and proven instructional strategies available for the aspiring and seasoned technology education teacher. Technology education can only be enhanced if varied instructional strategies are used, depending upon the content being taught.
5. Assessment of the instructional strategy being used is critical to its success. The technology teacher must continually assess the instructional strategy being used and make the necessary adjustments from data collected by the assessments.
6. It is okay (and expected) to try an instructional strategy and have only partial success. The successful teacher will learn from these experiences and continue to improve each instructional strategy accordingly.
7. The study of instructional strategies is dynamic and constantly being researched and improved. The successful technology teacher knows that in the future, new and emerging instructional strategies need to be included in the overall facilitation of the technology classroom.
8. One's educational philosophy, past experiences, and technological expertise may be one of the most important components in the selection of appropriate instructional strategies.
9. The future technology teacher will not only continually learn new content to be included in the classroom, but will also see a need to learn new instructional strategies to be used in the classroom.
10. The successful technology teacher is one who is confident and willing to change to new and innovative instructional strategies.
11. Research needs to be continued on many fronts in the field of instructional strategies. The editors of this yearbook encourage continued research in the area of instructional strategies. A sampling of suggested topics by future technology teachers may include:
    - Best teaching practices,
    - New models of learning theory,
    - New models for conceptual learning,
    - Innovative methods of making the technology education classroom more interdisciplinary,
    - Improved models showing success in modular environments,
    - Innovative methods to include problem solving and inquiry in the classroom,

- New models for cooperative learning,
- Improved methods to bring social and cultural impacts of technology into the classroom,
- Motivation in the technology education classroom as related to all instructional strategies,
- Success of instructional strategies in terms of learning, retention, and future use,
- The success of new and innovative instructional strategies not covered in this yearbook.

CHALLENGE FOR THE TECHNOLOGY TEACHER

Once again, the issue of selecting instructional strategies comes down to change. Just as the technology education profession needs to change the technology content to match the *Standards,* technology education teachers also need to change instructional strategies to match the needs of the students and our society today. As noted in the *Standards* (ITEA, 2000):

Resources based on the Technology Content Standards should:

- Incorporate varied methods of assessment.
- Include various teaching methodologies and student learning styles that address diversity.
- Include experiences and activities that enhance and promote hands-on learning, including problem-based and design-based learning (p. 19).

The successful technology teacher will view these resources as challenges and endorse them with vitality and enthusiasm.

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