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From the editor

As I ponder the current trends in vocational and science education, I become schizophrenic.... I'm not sure whether to be overwhelmed with optimism, or distraught with paranoia. It seems that in both camps, people are talking about us without necessarily calling our name.

Just as industrial arts education was forever changed by federal legislation in the 1970s, the Carl D. Perkins Act of 1990 promises to do the same for technology education. While it is impossible to project exactly *how* the Act will impact our profession, you can bet it won't be "business as usual" in the coming decade.

Among other initiatives, the Perkins Act seeks to encourage the integration of academic and vocational content. This would seem to bode well for technology education, since we have been working for more than a century to establish an optimal mix of the cognitive, psychomotor, and affective domains of learning. To the uninitiated, technology education may even appear to *be* the integration of academic and vocational curricula. In many technology education labs, it still takes more than a sidelong glance to appreciate the differing philosophies that underlie technology and vocational education. Yet, there is no clear mandate in the Act for technology education to assume a primary leadership role in this regard.

As the vocational and academic sectors grope to develop integration models, I would hope we in technology education would (finally) be recognized for our excellence in this arena. There is, of course, the danger of being subsumed in the process.

At the same time, the science education community is working around the clock to make their curricula more relevant, a task which has logically led them to consider "technology-based" activities. It is becoming increasingly difficult to differentiate between science and technology education content/methodology. The "Principles of Technology" course is a good case in point. Is it a science course or a technology course? Both, I guess, since it is being taught by both science and technology teachers. The activities described in progressive science textbooks mirror those found in progressive technology textbooks. At the risk of sounding repetitious, I would hope we in technology education would be recognized for our excellence in *this* arena as well.

At times, I think we *are* beginning to be recognized for our strengths in these areas. The recent reorganization of my State Department of Education has resulted in a new administrative position for technology education that appears to carry more clout than it used to. This was, however, an indirect result of more than two decades of strong state leadership in technology education in Virginia. And, it does not completely negate the net loss of technology education administrative positions resulting from the reorganization.

So what is to be made of the current trends in vocational and science education? Well, as usual, we have a lot of work to do to make others aware of the enormous contributions we have been making in education. As I read the reports on science and vocational education, I can't help but think we haven't given ourselves enough credit. They want technology-based activities... we've got 'em. They want an integration of academic and vocational content... check us out. We remain our own worst critics. It is time to get ourselves onto the ballot and let the public decide. °

Articles

Implementing Technology Education Problem-Solving Activities

V. William DeLuca

Teaching students how to solve problems is an important goal of education and industrial arts/technology education has had a long history of providing an environment for developing these skills. The congruence of technology education and problem solving is based on the fact that technologies are, in many ways, a product of problem solving. Technological problems require the application of knowledge from many different disciplines and the laboratory provides a medium to develop and test solutions.

Greenfield (1987, p. 20) suggests that students do not acquire thinking skills simply by practice in problem solving, drill, or osmosis. Problem-solving activities must be implemented with careful planning to insure intended student outcomes. Curriculum planning must involve careful consideration of the goals of problem-solving instruction, how an activity fits in relation to the goals, and the teaching style that would best facilitate goal attainment. Also, there is a difference between the product and the process when considering the value of problem-solving activities. Perkins (1986, p. 7) cautions against focusing on the products we produce and only indirectly the process by which we produce them. Specifically, how to proceed in a stepwise fashion to reach a goal. The essence of problem-solving is the application of knowledge and process that leads to a solution. Like any skill, the problem solver must acquire knowledge related to the problem, thinking skills needed to process this knowledge, and the ability to identify and apply appropriate processes to reach a solution.

Problem-Solving Processes

Problem solving is a process of resolving a known difficulty. Anderson (1980) emphasizes the processes undertaken during the act of problem solving

V. William DeLuca is Assistant Professor, Department of Occupational Education, North Carolina State University, Raleigh, North Carolina.

by defining this behavior as goal directed sequence of operations-- an organized sequence of mental steps. Accordingly, several different problem-solving processes have been documented. Brightman (1981) discussed a process model first proposed by John Dewey in 1933. The three step process included the diagnosis phase, analysis phase, and solution phase. Other, more specific, models have been described by Polya (1971), Soloway (1988), Bransford & Stein (1984), Hatch (1988), Seymour (1987), and Devore (1987). Following are summaries of these problem-solving processes.

1. Troubleshooting/Debugging: Isolate the problem, identify possible cause, test, implement solution, test solution.
2. Scientific Process: Observation, develop hypothesis, experimentation, draw conclusion.
3. Design Process: Ideation/brainstorm, identify possible solution, prototype, finalize design.
4. Research and Development: Conceptualize the project, select research procedure, finalize research design, develop proposal, conduct 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, evaluate the plan.

The problem type determines the appropriate process to select and use. Therefore, the task of the problem solver is to select the best process for a given problem. To select from these processes, the problem solver must understand each process and how and when to use the appropriate one. Advanced problem solvers perceive the process of solving problems as a cycle and selected processes or subprocesses are used when needed.

Thinking Skills

The mental abilities needed to solve problems are not fully understood because of the many levels and integrations of knowledge sets that are manifested in the act of solving problems. In its simplest form, problem-solving involves the application of recalled knowledge. Woods (1987, p. 55) discusses the importance of a knowledge base pertinent to the content of the problem and further explains the value of the problem solver's ability to identify, locate, and evaluate missing information needed in the problem-solving process. These thinking skills, as they relate to technology education, may be classified as follows:

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

Higher order thinking skills involve the processing of knowledge in memory. In this respect, thinking is the process of changing knowledge. Comparing ordinary thinking and good thinking, Lipman (1988, p. 40) uses terms such as estimating, evaluating, classifying, assuming, and hypothesizing to define good thinking. Similar thinking processes have been identified by Bloom (1956); Duke (1985); Kurfman & Cassidy (1977); and Feuerstein, Rand, Hoffman, & Miller (1980). Presseisen (1985, p.45) classified thinking skills as follows:

1. Qualifications — finding unique characteristics: units of basic identity, definitions, facts, problem/task recognition.
2. Causations — establishing cause and effect, assessment: predictions, inferences, judgments, evaluations.
3. Transformation — relating known to unknown characteristics, creating meanings: analogies, metaphors, logical inductions.
4. Relationships — Detecting regular operations: parts and wholes, patterns, analysis and synthesis, sequence and order, logical deduction.
5. Classification — determining common qualities: similarities and differences, grouping and sorting, comparisons, either/or distinctions.

This list encompasses the thinking skills presented in the literature. The five categories describe ways people mentally process knowledge to change its form and function.

Teaching Methods and Styles

When implementing problem-solving activities, the level of achievement is determined by the teaching methods used to initiate and maintain students' goal directed behaviors. Maley (1978) describes 15 teaching methods appropriate for industrial arts. Nader (1984) and Costa (1984) also referenced similar methods in addition to several other commonly used teaching methods. Refer to Table 2 column 4 for a listing of these methods.

Which of these methods are best for developing students' problem-solving skills? Given the diversity of technology education content and the need to teach basic content and skills, this question is not easily answered. When students have had no experience with the subject matter, recall is the starting point. Basic knowledge and skills may best be taught with a lecture-demonstration teaching approach. To develop problem-solving skills, Sternberg & Martin (1988), and Nickerson, Perkins, & Smith (1985) recommend deemphasizing lecture. These researchers point out the value of encouraging interaction between student and teacher and maintaining a balance between structure and unstructured learning environments.

The teaching style defines the interaction of student and teacher. The steps involved in developing problem-solving skills move the student from teacher dependence to independence. Sternberg & Martin (1988, p. 569) describe a four step process beginning with direct instruction followed by intragroup problem solving, intergroup problem-solving, and individual problem solving. The process begins by fostering teacher-to-student interaction then encouraging student-to-student interaction. When students internalize the problem-solving skills, individual problem-solving skills can be developed.

Problem-solving activities implemented in technology education are characterized by the problem-solving processes and thinking skills that are taught. The teaching method and teaching style determine the environment in which learning occurs. The interactions of these variables define the level of student development on the continuum of problem-solving performance.

Problem solving, whether direct or indirect, has long been a part of technology education because of the nature of technological content. To continue to develop and improve technology education problem-solving activities, it is worthwhile to establish a baseline that quantifies the best in current practices. The purpose of this study was to identify and describe problem-solving processes, thinking skills, teaching methods, and teaching styles typically used by technology education teachers that were recognized for their teaching excellence.

Methodology

Subjects

The sample consisted of 44 technology education teachers from the population of teachers recognized for their teaching excellence. Two groups of teachers were identified to participate in this study. One group consisted of the International Technology Education Association's 1989 Teacher of the Year award winners and members of the other group were nominated by state directors for technology/vocational education. State directors were asked to nominate teachers from their state who were noted for providing instruction of high quality and developing and/or implementing innovative learning experiences related to problem solving. Since the intent of this study was to describe the best in current practices, teachers of each group were asked to participate if they had successfully implemented innovative problem-solving activities.

Twenty-two of the 44 ITEA Teachers of the Year award winners participated in the study. Twenty-two teachers nominated by state supervisors participated. Twenty teachers taught high school students, 15 taught middle school students and 5 taught students at both the middle and high school level. Four teachers did not respond to the question regarding grade level.

Instrumentation

A survey instrument was designed to identify problem-solving activities that teachers had successfully implemented and variables associated with the implementation process. The survey consisted of two parts. In the first part, participants were asked to list and briefly describe one or more innovative problem-solving activities that they found to be positive student learning experiences. The second part of the survey contained 33 items. These items, included the variables that affect implementation of problem-solving activities as identified in the review of literature. A verbal frequency scale was used to measure the frequency of use of the five problem-solving processes described by Polya (1971), Soloway (1988), Bransford & Stein (1984), Hatch (1988), Seymour (1987), and Devore (1987); the eight thinking skills described by Woods (1987, p. 55) and Presseisen (1985, p.45); and the 17 teaching methods described by Maley (1978), Nader (1984) and Costa (1984). Four questions were used to measure the continuum of teacher-to-student interaction as described by Sternberg & Martin (1988), and Nickerson, Perkins, & Smith (1985). Participants recorded their responses to the second part of the survey on a CompuTest form using the following verbal frequency scale: A = always, B = usually, C = occasionally, D = seldom and E = never. For data analysis, these response categories were coded on a one (i.e always) to five (i.e never) point ordinal scale.

Results

The participants identified and briefly described 109 activities, an average of 2.5 activities per participant. Sixty-nine of these activities were different in title and description. The activities listed were used in a variety of grade levels ranging from 8th grade to post secondary. The subject area also varied. Teachers of CAD, construction, drafting, electronic communication, engineering, exploring technology, general technology education, graphics communication, industrial technology, introduction to industry, introduction to technology, manufacturing, power and energy, product design, transportation, and woodworking reported the activities.

Survey items were categorized according to problem-solving processes, thinking skills, teaching methods, and teaching styles. These items were used to determine typical techniques used by the teachers surveyed when they implemented problem-solving activities.

A cluster analysis, the Ward's Method, was used to classify the set of variables into homogeneous groups based on similarity of response. With this analysis, the mean verbal frequency scores of each item were grouped to minimize the overall sum of squared within-cluster distances. Therefore, the clusters represent questionnaire items that shared similar frequency of use when teachers implemented problem-solving activities. To understand the similarity of the items in each cluster and the differences between the five clusters, Table 1 shows the characteristic response that items in each cluster share. For clarity the clusters were labeled according to mean rank of cluster characteristics, therefore cluster one represents items most frequently used and cluster five represents items least frequently used.

Table 1
Cluster Characteristics

Cluster	Mean	MDN	SD
1	2.30	2.0	.966

2	2.68	3.0	1.11
3	3.07	3.0	1.20
4	3.18	3.0	1.12
5	3.96	4.0	1.08

The five clusters are summarized in Table 2. Cluster one contained eight items. One problem-solving process, the design process, was a member of this cluster. The thinking skills in this cluster included application of related knowledge gained from classes other than technology education and prior technological knowledge gained from technology education class. The teaching style clustered in this group was described as the teacher shared goals and objectives with the student and decisions

Table 2
Cluster Groupings of Survey Items

Cluster	PS Process	Thinking Skills	Teaching Methods	Teaching Style
1	Design Process	Related Knowledge	Discussion	Goals are shared by teacher. Decisions reached through agreement.
		Prior Technological Knowledge	Demonstration	
			Experimentation	
			Lecture	
2			Individual Instruction	Goals are set by teacher. Teacher facilitates goal attainment.
			Media	
3	Troubleshooting		Discovery	Teacher directs all learning experiences.
	Scientific		Simulation	
	Project Management		Readings	
	Research & Develop		Game-Structured Competition	
4		Classification	Competency-based	
		Causations		
		Qualifications		

	Relationships		
	Knowledge Seeking		
5		Seminar Scenario Contract Case Study Panel Discussion Role Play	Student develops goals and means to reach them.

were reached through agreement. The characteristics of this cluster, listed in Table 1, indicate that these methods were the most frequently used by technology teachers with a mean of 2.30. Sixty-one percent of the teachers surveyed used the items listed in this cluster usually or always and 98.3% used them at least sometimes.

Cluster two was characterized by mean of 2.68. Four items were always or usually used by 43.9% of the teachers. Individualized instruction and media were teaching methods grouped in this cluster. The teaching style, like the teaching method, was teacher directed with goals and objectives set by the teacher and the teacher guided goal attainment. These methods and this style are conducive to attainment of basic level knowledge that is a prerequisite to successful problem solving.

Cluster three contained items typically used often by the teachers surveyed. The mean response for items in this cluster was 3.07 with 34.8% of the teachers using them always or usually. Four of the five problem-solving processes were part of this cluster. They included troubleshooting/debugging, scientific process, research and development and project management. Teaching methods included in this cluster were discovery, simulation, and reading. The teaching style that was close to the mean of this cluster was one where the teacher directed all learning experience. Six of the eight thinking skills were grouped in cluster four. Competency based instruction was also grouped in this cluster. The characteristics of cluster four were similar to cluster three with 33.8% of the teachers using the members of this cluster usually or always.

The items with the lowest frequency, typically seldom used, were grouped in cluster five. This cluster was characterized by a mean of 3.96 with 9.7% of the teachers surveyed indicating that they used the teaching methods and style usually or always. Seminar, scenario, contract, case study, panel discussion and role play were members of this cluster. Also, the teaching style that was defined as students develop goals and objectives and the means to reach them was seldom used by the teachers surveyed.

Discussion

Problem-solving activities develop important skills. They teach students how to think and provide them with opportunities to experience knowledge seeking, selection, application, and evaluation. Implementing problem-solving activities means more than just giving students assignments. The outcomes of activities are dependent on the problem-solving processes and thinking skills that are taught and applied. The environment that fosters problem solving is created by the teaching methods and styles that define the teacher-to-student and student-to-student interaction.

This study identified elements of problem-solving activities that were frequently used by a sample of technology education teachers recognized for their teaching excellence. The inferential qualities of the data are limited due to the sample size, but the cluster analysis does establish norms for describing the characteristics of technology education problem-solving activities. The typical activities required students to apply knowledge gained in technology education class as well as other classes. The design process was used to structure a procedure for reaching a solution. Lecture, discussion, demonstration, and experimentation were methods most frequently used to implement activities. Teachers typically shared the goals of the activity with students and decisions were reached through agreement.

The results represent a hierarchal paradigm that emphasizes the design process and application of knowledge learned in school. Four of the five problem-solving processes and six of the eight thinking skills were typically used occasionally. Increasing the application of those elements less frequently used could be the focus for improving technology education problem-solving activities. Relating to thinking skills, Feuerstein, Miller, Hoffman, Rand, Mintzker & Jensen (1981) have shown that the development of thinking skills increases problem-solving performance. Narrol, Silverman & Waksman (1982) have shown that remedial students in vocational education programs benefit from thinking skill instruction.

The teaching methods used by teachers represent techniques that are associated with teaching low as well as high level cognitive skills. As discussed by Nickerson, Perkins, & Smith (1985, p. 327), the use of several teaching methods is common when implementing problem-solving activities. Often students need to gain basic knowledge to apply to the solution especially in a new area of study. The sequence of instruction then leads students to methods such as experimentation, game structured competition, and discovery that give them a more active role in knowledge seeking. The teaching methods listed in cluster five were seldom used by the teachers surveyed. These methods are associated with developing cognitive skills associated with effective problem solving. Likewise, the teaching style used least frequently (cluster five) is associated with high-level performance. Methods such as case study, contract and scenario could be used to focus activities on current technological problems.

This study showed that technology education is providing students with experiences, as defined by the literature cited, that develop valuable problem-solving skills. To improve technology education problem-solving activities, the intent of instruction and scope of problem-solving skill developed are the issues. If the intent of instruction is to focus on certain elements and treat others as subsets then a hierarchal paradigm should be the focus for further development. If the elements are to be treated with equal value then a paradigm representing a balance in scope should be pursued. With this paradigm, students should be taught to identify the problem type and select the appropriate process.

As problem-solving activities continue to evolve, educators must insure that appropriate processes and thinking skills are taught and teaching methods and styles allow students to grow. Curriculum developers should consider the variables identified and described in this study to analyze the paradigm that characterizes the learning potential of problem-solving activities within the scope and sequence of technology education instruction.

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Assessing the Effectiveness of the Change to Technology Teacher Education

Daniel L. Householder & Richard A. Boser

Many institutions which formerly prepared teachers of industrial arts are currently implementing technology teacher education programs. As these institutions change to implement technology teacher education, it is important to obtain an accurate assessment of the effectiveness of the innovation. Change in the teacher education curriculum may be assessed in a number of possible ways, each with several potential advantages. However, there is no generally accepted model for assessing the overall effectiveness of such a major change in technology teacher education.

To address this problem, a study was undertaken to develop and verify a set of measures that could be used to assess the effectiveness of the move to technology teacher education. Specifically, the study sought answers to two research questions: "What measurements should be used to determine the effectiveness of the change?" and "How should these measurements be validated?"

Background

The literature relevant to the assessment of change and program implementation may be categorized into three areas: (a) educational program evaluation; (b) program evaluation in higher education, specifically in teacher education; and (c) change and program implementation in teacher education programs. Studies in each of these areas were reviewed to establish the research base for the development of the formative evaluation system for technology teacher education programs.

Educational Program Evaluation

In a literature search for an applicable model for the evaluation of teacher education programs, Ayers, Gephart, and Clark (1989) reported "approximately 40 references to evaluation models" (p. 14). Stufflebeam and Webster (1980) identified and assessed 13 alternative evaluation approaches in terms of their adherence to the definition: "an educational evaluation study is one that is designed and conducted to assist some audience to judge and improve the worth

Daniel L. Householder is Professor and Richard A. Boser is a Graduate Assistant in the Department of Industrial, Vocational and Technical Education, Texas A&M University, College Station, Texas.

of some educational object" (p. 6). Their analysis resulted in three categories of evaluation studies: (a) politically oriented, or pseudo evaluations; (b) question oriented, or quasi- evaluations; and (c) values oriented, or true evaluations. Stufflebeam and Webster addressed the strengths and weaknesses inherent in each evaluation approach in order to provide evaluators with a variety of frameworks for conducting evaluation studies.

However, as Popham (1975) noted, comparing evaluation approaches in order to select the best model is usually a fruitless endeavor. Popham stated:

> Instead of engaging in a game of "sames and differents," the educational evaluator should become sufficiently conversant with the available models of evaluation to decide which, if any to employ. Often, a more eclectic approach will be adopted whereby one selectively draws from the several available models those procedures or constructs that appear most helpful. (p. 21)

Cronbach (1982) echoed this need for eclecticism by noting that "the [evaluation] design must be chosen afresh in each new undertaking, and the choices to be made are almost innumerable" (p. 1). Indeed, an eclectic approach seemed most appropriate for the formative evaluation of the change to technology teacher education.

The review of the evaluation literature identified two approaches that could be combined to develop appropriate instrumentation and procedures. These were the Context, Input, Process, and Product (CIPP) Model originated by Stufflebeam et al. (1971), and the Discrepancy Model proposed by Provus (1971). These models have many commonalities. Both models:

1. Were conceptualized and developed in the late 1960s in response to the need to evaluate projects funded through the Elementary and Secondary Education Act (ESEA) of 1965.
2. Represented efforts to broaden the view of educational evaluation to include more than an assessment of the terminal objectives.
3. Emphasized the systems view of the education by stressing the relationship between context, inputs, processes, and products.
4. Emphasized the importance of collecting information on key developmental factors to aid decision-makers in assessing program progress at a given point (Brinkerhoff, Brethower, Hluchyj, and Nowakowski, 1983).
5. Were concerned with the developmental aspects of program design and implementation, and recommended close collaboration with program developers.
6. Have been used in a variety of evaluation environments (Roth, 1978; Provus, 1971; and Stufflebeam, et al., 1971), though they are not specifically designed for the evaluation of teacher education programs.

The CIPP Model. Bjorkquist and Householder (1990) noted that "programs in which goals are accomplished are usually considered to be effective"

(p. 69). In an overview and assessment of evaluation studies, Stufflebeam and Webster (1980) stated that the objectives-based view of program evaluation "has been the most prevalent type used in the name of educational evaluation" (p. 8). Indeed, prior to the ESEA, educational evaluation had focused upon "the determination of the degree to which an instructional program's goals were achieved" (Popham, 1975, p. 22). However, a group lead by Stufflebeam proposed an evaluation process that focused upon program improvement by evaluating virtually all aspects of the educational program. Stufflebeam (1983) stated:

> Fundamentally, the use of the CIPP Model is intended to promote growth and to help the responsible leadership and staff of an institution systematically to obtain and use feedback so as to excel in meeting important needs, or at least, to do the best they can with the available resources. (p. 118).

In short, the CIPP Model placed a premium on information that can be used proactively to improve a program.

Discrepancy Model. This model was developed to be put in place as the new programs were designed and implemented in the Pittsburgh public schools. A systems approach was used to determine whether program performance met accepted program standards. Provus (1971) conceptualized a three-step process of program evaluation: (a) defining program standards, (b) determining whether a discrepancy exists between some aspect of program performance and the standards governing that aspect of the program, and (c) using discrepancy information either to change performance or to change program standards (p. 183). According to Provus, this operational definition of program evaluation leads to four possible alternatives: (a) the program can be terminated, (b) the program can proceed unaltered, (c) the performance of the program can be altered, or (d) the standards governing the program can be altered (Popham, 1975).

The Discrepancy Model has five stages: (a) design; (b) installation; (c) process; (d) product; and (e) program comparison. Provus (1971) noted that, "at each of these stages a comparison is made between reality and some standard or standards" (p. 46). The first four stages are developmental in nature and designed to evaluate a single program. The fifth stage, which Provus designated as optional, provides information for making comparisons with alternative programs.

Merging the evaluation models. With the commonalities of the two models previously stated and the thoroughness of the CIPP Model reviewed, one might well ask why the two models should be merged. The answer lies in the complementing strengths of the two models. CIPP, with its use of both quantitative and qualitative procedures and its emphasis on proactive evaluation, provides an overarching evaluation model. Because of its thoroughness, it is also extremely expensive and time consuming. As Stufflebeam and Webster (1980) noted, values-oriented studies, such as CIPP, aimed at assessing the overall merit or worth of a program are overly ambitious "for it is virtually impossible to assess the true worth of any object" (p. 18). However, the CIPP model provides an excellent framework for approaching the multitude of possible variables in program evaluation.

What does the discrepancy evaluation model add to this customized assessment approach? Stufflebeam and Webster (1980) stated that question-oriented studies that focus on program objectives or standards "are frequently superior to true evaluation studies in the efficiency of methodology and technical adequacy of information employed" (p. 18). In particular, the discrepancy model championed by Provus adds three useful constructs to the evaluation process:

1. The broadening of the evaluation procedure to include the possibility of altering the standards to conform with reality. In light of the current emphasis on standards external to the program, such as National Council for Accreditation of Teacher Education (NCATE) criteria, this approach seemed particularly appropriate.
2. The emphasis upon high-fidelity implementation addressed major concerns in the change process.
3. The emphasis upon problem solving solutions to program performance alteration appeared to be consistent with the espoused philosophy of technology education.

Since technology teacher education programs are still largely in the implementation stage, assessments of their effectiveness could most profitably focus on discrepancies between the performances and standards that are concerned with the inputs and the processes of the technology teacher education programs. Taken together, it seems reasonable to consider an evaluation approach that focuses on input and process evaluation components as Stufflebeam uses the terms by comparing actual performance with defined standards.

Program Evaluation in Teacher Education

Few studies have related specific program evaluation approaches to the assessment of teacher education programs. Perhaps the dearth of references in the literature to specific evaluation approaches used in teacher education programs is the result of the emphasis placed on the accreditation of those programs. Accreditation procedures require that teacher education institutions periodically undertake systematic formative and summative evaluations. Taking this reality into consideration, Ayers, Gephart, and Clark (1989) proposed the Accreditation Plus Model that integrates the accreditation process and existing evaluation approaches. While focusing on the National Council for Accreditation of Teacher Education (1987) standards and criteria for compliance, the model suggests a process that is "active, continual, and formative" (p. 16).

The Accreditation Plus Model seems to be a logical extension of an already required practice. While this model was designed to be used for the evaluation of professional educational units, the process seems adaptable to the more specific evaluation concerns of technology teacher education programs.

Change and Program Implementation

Gee and Tyler (1976) suggested that "reasonable people will assume moderate risk for great benefits, small risks for moderate benefits, and no risk for no benefit" (p. 2). While this statement makes explicit the personal nature of the change process, organizational characteristics are also important factors in facilitating change. Hopkins (1984) argued that the nature of the educational organization itself is a major impediment to change. He noted that in spite of considerable external pressure for change in teacher education, there were few observable differences in the routines of professors and students. Hopkins made the provocative suggestion that "teacher training institutions as organizations appear unable effectively to manage self-initiated change" (p. 37). Giacquinta (1980), even less charitable, suggested that schools of education find that "change is a necessary, often bitter pill taken for the sake of survival" (Hopkins, 1984, p. 43). These opinions seem to be shared by several state legislatures which have recently mandated changes in teacher education requirements and practices.

A Model for Organizational Change

A model of the innovation-decision process in an organization, developed by Rogers (1983), focuses on the process of adoption, implementation, and the incorporation of the innovation into the organization. The five steps in the model are divided into two stages: initiation and implementation.

Initiation Stage. During this stage, organizational activities center around the information-gathering, conceptualizing, and planning that is required to make the decision to change. The two steps included at this stage are: (a) agenda setting, where the initial idea search occurs and the motivation to change is generated; and (b) matching, where organizational problems and possible solutions are analyzed for compatibility.

The initiation stage is essentially a problem solving exercise. As the organization becomes cognizant of a performance shortfall, it initiates a search of the environment for possible solutions to the problem. For example, industrial arts programs were generally faced with declining enrollments. At the same time, many studies cited the need for students to possess increased scientific and technological literacy. In response, the field started to focus on technology education as an emergent solution to both problems.

Implementation Stage. The second stage, implementation, begins after the decision to make the change has been made by the organization. This stage includes the decisions, actions, and procedures involved in putting an innovation into regular use. The implementation stage includes three steps: (a) redefining/restructuring the innovation and the organization to accommodate the change; (b) clarifying the innovation as it is put into regular use; and ultimately (c) routinizing or institutionalizing the change as an integral part of the ongoing activities of the organization.

According to Rogers (1983) each step is "characterized by a particular range of events, actions, and decisions" (p. 362). Further, the latter steps cannot occur until the issues in the earlier steps have been resolved. Citing the work of Pelz (1981) as a source of support for the model, Rogers noted that innovations imported into an organization "usually occur in the time-order sequence" (p. 366). However, innovations that originated within an organization are not characterized by a similarly clear pattern of adoption. Since technology teacher education programs are currently changing in an attempt to meet largely external innovations (NCATE accreditation standards and state certification requirements), it appears that the time-order sequence is expected to apply. The linear nature of the innovation-decision model highlights the need to nurture the change to technology teacher education throughout the stages of the entire change process.

Summary

In light of the review of literature and the specific goals of this research effort, the decision was made to develop an evaluation design incorporating an eclectic mix of program evaluation approaches, the NCATE accreditation process, and descriptions of the process of change as that process may be expected to occur in teacher education organizations. Stufflebeam's CIPP Model provided an overall framework from which to assess the effectiveness of change to technology teacher education. Provus's Discrepancy Model added the possibility of adjusting the measurement standards to conform to program performance reality. And, because accreditation is an overarching evaluation concern for teacher education, the Accreditation Plus Model suggested a way of integrating program evaluation and accreditation. Further, because technology teacher education programs are presently in the early implementation stage, measures that reflect the process of change seemed to be appropriate for inclusion.

Procedures

A modified Delphi design was used in this study. Nominations of leading practitioners and advocates in technology education who might serve as Delphi panelists were solicited from officers of the Council on Technology Teacher Education and the International Technology Education Association. This process resulted in the selection of a panel comprised of the 22 individuals who were recommended by at least two of the CTTE or ITEA officers.

On an open-ended questionnaire, panelists were asked to suggest criteria and procedures for evaluating the effectiveness of the change from industrial arts teacher education to technology teacher education programs. Fourteen panelists returned the first round questionnaire. The reponses were tabulated, duplications were eliminated, and similar suggestions were combined. This process resulted in a list of 58 criteria and 33 procedures for evaluating the effectiveness of the change to technology teacher education. The criteria were sorted into four categories: (a) the technology teacher education program, (b) faculty members, (c) student skills, and (d) capabilities of graduates.

The second round questionnaire asked the 22 panelists to rate the importance of the 58 criteria and 33 procedures on a scale which ranged from 0 to 10. The instructions defined a rating of 0 as a recommendation that the criterion or procedure be dropped. A rating of 10 meant that the criterion or procedure was considered to be absolutely vital to the assessment of the effectiveness of the change to technology teacher education. Panelists were asked to offer editorial suggestions on the statements of criteria and procedures and also to suggest additional criteria and procedures (and to rate any additional statements).

Eighteen of the 22 second round questionnaires were returned promptly. The responses were tabulated and the mean rating of importance for each item was calculated. The statements of criteria and procedures were then listed in order of their mean rating of importance. The ranked listings for each criterion with a mean value greater than 9.0 on the 10 point scale are included in Table 1.

Table 1
Highly Ranked Criteria and Procedures Sorted by Category

Mean	Criteria and Procedures
Technology Teacher Education Program ...	
9.55	Laboratory instruction provides opportunities for students to reinforce abstract concepts with concrete experiences.
9.50	Instructional strategies emphasize conceptual understanding and problem solving.
9.23	Professional studies component emphasizes the study of technology, including social-cultural affects.
9.22	Laboratories facilitate the learning of broad based technological concepts.
9.22	Instruction incorporates current technological activities.
9.17	Philosophy, mission statement, goals and curriculum emphasize technological skills rather than technical skills.
9.17	Social-cultural impacts of technology are emphasized.
9.12	Field experiences are technology centered.
9.05	Problem solving and decision making abilities are emphasized.
9.00	Curricula are based on recent research findings.
Faculty Members ...	
9.50	Display a positive attitude toward the technology teacher education curriculum.
9.22	Participate in planned professional development activities to update their knowledge and skills.
9.05	Communicate their understanding of the meaning and impli-

cations of technology education both within and outside the classroom.

Students are expected to ...

9.78	Be people oriented.
9.44	Be future oriented.
9.39	Demonstrate the ability to teach problem solving techniques.
9.33	Effectively plan and implement technology education in grades 5-12.
9.28	Develop and implement curriculum material that reflect a broad technological system area.

Table 1 (cont.)

9.28	Demonstrate an awareness of society's reliance on technological systems.
9.22	Plan and implement teaching-learning activities.
9.17	Use a vocabulary that reflects the concepts of technology education.
9.11	Apply current instructional theory.
9.06	Formulate appropriate objectives.
9.05	Be open to change and willing to initiate change.
9.05	Consider global perspectives in technology education.
9.00	Demonstrate a basic understanding of tools, machines and process and their applications in manufacturing, construction, communication, and transportation.
Graduates of the technology teacher education program ...	
9.78	Employ a philosophy which reflects a technological base.
9.61	Teach concepts and use teaching techniques that are technology based.
Procedure Statements ...	
9.50	Examine the curriculum to determine if the philosophy, definition, mission statement, goals and objectives, course content, and learning experience reflect technology education.
9.22	Analyze the courses required in the program, the content contained in each of the courses, teaching strategies and methods, assignments, tests, and student field experience to determine if they reflect technology education.

Developing the Technology Teacher Education Checklist (TTEC)

An initial review of the listing of criteria and procedures identified by the panelists in this research suggested many parallels to the NCATE approved curriculum guidelines as specified in the *Basic Program in Technology Education* (1987). The intent of this investigation was not to duplicate the NCATE assessment process, but to identify essential elements in the implementation of technology teacher education that would serve as key indicators of the effectiveness of the change from industrial arts teacher education. In order to concentrate the assessment effort, therefore, criteria were selected for inclusion in the measurement instrument if they were:

1. Highly ranked within their criteria category but not addressed by NCATE curriculum guidelines;
2. Correlated to NCATE curriculum guidelines for technology teacher education and distinctly different from usual practices in industrial arts teacher education; or
3. Considered to be essential to support the process of organizational change.

Other suggested items were not included in the TTEC because they were measurements of program outcome, such as performance of program graduates. These items were excluded from the measurement instrument since technology teacher education is in the implementation phase, a stage when Hall and Hord (1987) noted that "interpreting any outcome data is extremely risky" (p. 343).

Further, the procedures proposed for this formative evaluation design were purposely limited by the following criteria:

1. The time required for on-site data collection by the external evaluator(s) should not exceed two observer-days.
2. With the exception of interviews and classroom and laboratory observation sessions, the data gathering should not require additional faculty time.
3. Existing data should be used whenever possible.
4. Data gathering should not seriously disrupt on-going instructional activities.

In this way, the evaluation may be conducted in a reasonable time with a minimum of disruption to departmental activities.

Verification of the TTEC

In order to verify the measures selected for inclusion in the checklist, a draft of the TTEC was sent to the panel for editorial suggestions and additional comments. Sixteen of the twenty-two panelists responded. Most respondents suggested editorial revisions or made other comments. Careful consideration was given to these suggestions as revisions were made in the TTEC. The TTEC, revised to incorporate suggestions from panelists, is reproduced below.

Technology Teacher Education Checklist

1. Examine the catalog, a sample of curriculum documents, and a sample of course syllabi to verify the degree to which:
   a. The philosophy, mission statement, and goals and objectives of the program reflect the definition(s) of technology education suggested by ITEA, CTTE, and relevant groups in the state/province.
   b. Study is required in technological systems such as communication, production (construction and manufacturing), transportation, and biotechnology.
   c. Courses in mathematics, science, and computing science are required.

   d. Required full-time student teaching and early field experiences are conducted in an exemplary technology education setting.
   e. Required reading lists provide comprehensive coverage of technology and technology education.
   f. Learning activities and experiences are representative of technology education.
2. Interview the department head with regard to the change to technology teacher education to discern the degree to which:
   a. Funding is adequate to support the current technology teacher education program and plans are in place for periodic replacement and upgrading of facilities and equipment.
   b. Faculty and staff allocations are adequate to serve student enrollments in technology teacher education.
   c. The written departmental plan for faculty professional development and technological updating is adequate to prepare faculty members for contemporary technology teacher education.
   d. Enrollments in the major are adequate, stable, or increasing.
   e. The written departmental implementation plan for technology teacher education addresses the process of organizational change.
   f. Faculty are committed to the philosophy and objectives of technology education.
3. Interview faculty members and review recent annual reports, biodata information, faculty publications, copies of presentations, and manuscripts being considered for publication to verify whether:
   a. Faculty are writing scholarly papers, developing instructional materials, and giving presentations about technology education.
   b. Current faculty research and service activities are directed toward topics and issues in technology education.
   c. Faculty are actively involved in professional organizations in technology education.
4. Observe professional and technical classes to discern the degree to which:
   a. Instructional methods emphasize technological problem solving and decision-making.
   b. Instructional materials reflect contemporary technology.
   c. Major elements of technology education (e.g., systems, environmental and social impacts, and the applications of technological devices) are emphasized in the course activities.
5. Inspect laboratory facilities to ascertain the degree to which:
   a. Laboratories are adequate for effective instruction.
   b. Equipment and space provide students adequate opportunities for experiences in state-of-the-art applications of technology (e.g., CAD/CAM, CIM, robotics, desk-top publishing, lasers, table-top technology, hydroponics).
6. Interview students, and examine student logs and required student work to discern whether:

   a. The elements of technology education are understood and integrated into their total philosophy of education.
   b. They are active in a TECA chapter.
   c. The problem solving process and decision-making rationale are incorporated into grading.
   d. Environmental consequences and social-cultural effects of technology are reflected in student activities.
7. Interview chairs of related departments and administrators (dean, provost, or president) to ascertain the degree of philosophical support that is provided for technology education.
8. Listen to conversations and discussions and observe student activity to discern the degree to which:
   a. The terminology used by faculty and students reflects technology and technology education.
   b. Faculty and students appear to be enthusiastic about technology education.
9. Interview principals who have experience with student teachers and graduates of the technology education program to discern whether the program prepares professionals to:
   a. Plan and implement technology education.
   b. Use problem solving strategies.
   c. Apply current instructional theory.

Using the Instrument

Jordan (1989) began a discussion of evaluation and change by reminding practitioners that:

> One of the axioms of measurement is that assessment is not an end in itself. We evaluate because we wish to know the current state of affairs, but we wish to do that in order to make improvements. Exactly how we wish to improve depends on what we discover. In theory, the process is circular and unending. That is, we should assess and make improvements and then assess the improvements. (p. 147)

With this interaction between evaluation and change in mind, there are several possible ways of using the instrument developed through this research. Perhaps the simplest use would be for an internal or external evaluator to use the instrument as a checklist of what has been accomplished and what is in progress (or still to be initiated). Two more complex uses may include determining if the innovation is in place and using force field analysis to determine sources of resistance.

Determining if the Innovation is In-Place

Hord, Rutherford, Huling-Austin, and Hall (1987) proposed that before assessing program outcomes it is first necessary to determine that the innovation is in fact in place. They indicated two ways of making that determination: (a) first, the level of fidelity of the actual implementation of the innovation can be compared with the intended innovation, and (b) second, the actual levels of use can be determined. Hord et al. proposed that each innovation has essential and related components. The essential components cannot be changed without undermining the nature of the innovation itself. The related concepts allow for local flexibility and, while varied, are still faithful to the innovation design. Hord et al. suggested that assessment of fidelity can be made by developing a checklist that outlines ideal, acceptable, and unacceptable variations of the innovation. In technology teacher education programs, many of the criteria identified through this research may serve as the "essential" components.

The second measure proposed by Hord et al. (1987) to determine whether or not the innovation is actually in place is an assessment of the six levels of use. These levels range from Level of Use 0 (nonuse) to Level of Use VI (renewal) where the "user reevaluates the quality of use of the innovation, seeks major modifications of or alternatives to, present innovation to achieve increased impact on clients, examines new developments in the field, and explores new goals for self and the organization" (p. 55). By using the TTEC to identify the essential components of the change to technology teacher education, an assessment of levels of use from the perspective of the faculty may be an important step in measuring the effectiveness of the change and planning further intervention strategies.

Force Field Analysis

Lewin (1951), the originator of field psychology, proposed that change is the result of competition between driving and resisting forces. Lewin's conceptualization has been adapted to describe the dynamics of a number of management situations in organizational change. Daft (1988) stated that:

> To implement a change, management should analyze the change forces. By selectively removing forces that restrain change the driving forces will be strong enough to enable implementation. . . . As restraining forces are reduced or removed, behavior will shift to incorporate the desired changes. (p. 313)

Miller (1987) suggested that force field analysis could be used to nurture a climate receptive to innovation and creativity. Miller stated:

> The primary function of the force field in idea generation is to present three different stimuli for thinking of new options or solutions. Because the field represents a kind of tug-of-war, there are three ways to move the center line in the direction of the more desirable future:
>
> 1. Strengthen an already present positive force.
> 2. Weaken an already present negative force.
> 3. Add a new positive force. (p. 73)

If these two ideas are taken together, a picture emerges of how force field analysis and the instrument designed through this research could be applied to the transition from industrial arts teacher education to technology teacher education. First, each criterion could be assessed to determine its relative strength as a driving force for change. Additionally, forces unique to the particular implementation may be identified and dealt with. Second, the information generated through the assessment could be used to strengthen the implementation procedures. In this way, the instrument may serve as a game plan for implementation and continued assessment of the change.

Implications

The Technology Teacher Education Checklist, which was the primary outcome of this research, should be useful to the faculty of a technology teacher education program or to an external evaluator in conducting formative or summative assessments of the change to technology education. While its use requires minimal duplication of the NCATE approval procedures, the items in TTEC focus upon key indicators of effective change to technology teacher education. The TTEC might be especially useful in a review of a technology teacher education program, a year or two in advance of the preparation of a curriculum folio to be submitted for consideration for NCATE approval.

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Productivity, the Workforce, and Technology Education

Scott D. Johnson

While the United States was once the premier leader in industrial strength and influence, countries previously unable to compete with the United States in both technological and economic arenas have made drastic changes in the way they develop and produce goods. Through modernization of their factories and by using innovative organizational systems, these so called non-industrial countries have begun to compete with the industrial giants on their own turf. New competition from countries such as Japan, Korea, and Brazil is having a dramatic impact on the economic, political, and educational systems within the United States. Examples of the results from this new competition include rising trade deficits, an increasing budget deficit, slow productivity growth, stagnant real wages, and a declining share of world markets (Young, 1988). All of these trends constitute a threat to the American standard of living. Unless changes are made to increase the competitive ability of the United States on economic and technological grounds, the quality of life in this country is certain to fall.

In response to the competitiveness problem, this country must strive to develop a highly skilled, adaptable workforce that develops and uses technology. This effort would result in a renewed competitive advantage through improved technologies and innovative, creative, and highly educated workers; something which may be the United States' biggest strength. This approach is not without its drawbacks. New technologies are likely to replace many workers which could result in higher unemployment. Advances in technology could also lead to a deskilling of the workforce which may result in a wider gap between the workers who develop new technologies and those who use them.

To return the United States to its former competitive status, improvements must occur in the productivity of the workforce. Technology education has a unique role to play in improving the productivity of the future workforce (Technology Education Advisory Council, 1988). In addition to providing students with the opportunity to interact with technological systems and proc-

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Scott D. Johnson is Assistant Professor and Chair, Technology Education Division, Department of Vocational and Technical Education, University of Illinois at Urbana-Champaign, Champaign, Illinois. The preparation of this paper was supported in part by a grant from the Illinois State Board of Education; Department of Adult, Vocational, and Technical Education; Program Improvement Section.

esses, technology education reinforces the content learned in other curricular areas and enhances higher order thinking skills. Before expanding on the role of technology education in improving the productivity of the future workforce, an examination of the productivity issue and the impact of technology on the workforce is needed.

Improving Workforce Productivity

The United States must improve its level of productivity in order to become more competitive. It has been said that productivity is the main determinant of trends in living standards (Hatsopoulos, Krugman, & Summers, 1988). Therefore, if Americans are to continue enjoying their high standard of living, they will have to find ways to continually increase their own productivity. Recent evidence shows that competitors have been able to increase their productivity at a much faster rate than the U. S. For example, the U. S. was ranked below eleven of its competitors in productivity growth from 1973 through 1979 and from 1981 through 1985 (Berger, 1987; Klein, 1988). While the statistics point out weaknesses, all is not lost. After the dismal years of the 1970s and early 1980s, U. S. companies have shown productivity improvements in recent years. In 1985, the U. S. had the second highest growth in productivity among the twelve leading industrial countries with a 5.1% increase and in 1986 had the highest productivity growth at 3.7% (Klein, 1988).

While the recent improvements are encouraging, efforts must be made to ensure that these improvements in productivity continue. There are three primary ways to improve productivity: (a) through the development of new technologies, (b) through increased capital expenditures, and (c) through education and training.

Improve Productivity Through the Development of New Technologies

Eighty percent of the U. S. productivity growth can be attributed to technological innovation (Young, 1988). A strong research and development effort is needed to ensure that new innovations are forthcoming. Without research and development expenditures, it is doubtful that significant innovations can be developed. While the U. S. has been successful in developing new technologies in the past, it not likely to continue to be successful if current trends continue. Business and government expenditures for civilian research and development are a smaller proportion of the economy in the U. S. than in other developed countries (Berger, 1987). A continued commitment and support for research and development must be made if the U. S. is to maintain its leadership in the development of technological innovations.

Improve Productivity Through Increased Capital Expenditures

While the development of technology is a key to productivity growth, the technology is worthless unless it is actually used. A primary reason the U. S. has lost its competitive advantage in the steel and automobile industries is because those industries have been slow to realize that modern facilities, new equipment, and innovative organizational strategies are needed to keep up with the rest of the world. In recent years, U. S. competitors have been tooling up with modern facilities that incorporate the latest technologies and strategies such as robotics, computer-integrated manufacturing, just-in-time manufacturing, and the Japanese philosophy of Kaizen. At the same time, U. S. steel and automotive industries were trying to produce goods in antiquated facilities with pre-World War II technologies and traditional authoritative management strategies. The result of the unwillingness of these U. S. industries to expend the necessary capital to build new facilities and to acquire new technologies has been a decreased share of world markets, increased layoffs, and reduced profit margins. As an example of the discrepancy between U. S. capital expenditures and those of Japan, the Japanese spend 50% - 100% more per employee on capital than the U. S. To compound the problem, U. S. capital costs 50% - 75% more than Japanese capital (Hatsopoulos, Krugman, & Summers, 1988). On a positive note, the recent surge in productivity in the U. S. can be partially attributed to the willingness of companies to begin investing in new capital.

Improve Productivity Through Education and Training

As stated by the *President's Commission on Industrial Competitiveness* (1985), this country has failed to develop its human resources as well as other nations. This problem becomes evident when comparing our educational system with those of other countries. Only 70% of the students in American schools successfully complete high school while 98% of Japanese students complete high school (Jonas, 1987). The recent plethora of national reports that focus on educational reform further support the need for strengthening America's educational systems (Carnegie Forum, 1986; National Commission on Secondary Vocational Education, 1984; Parnell, 1985).

Even if the U. S. is able to continue developing new technologies and makes the capital expenditures necessary to utilize those developments, great improvements in productivity will be unlikely unless workers have the level of education and skill needed to handle the advanced technologies (Berger, 1987). In response to this need, educational programs at the secondary and post-secondary levels need to identify the knowledge and skills that will be needed by the future workforce to successfully work with and maintain the advanced technologies and develop appropriate delivery systems for the teaching of the new content.

The Impact of Technology on the Workforce

There are several views regarding technological advancement and its effect on the workforce (Naylor, 1985; Rumberger, 1984). One view is that technological advances will be the primary source of new jobs in the future. People read and hear about new jobs being created in the areas of robotics, computers, lasers, and optics. A common belief is that jobs in these areas are completely new and will result in job opportunities for a great many workers. The second view is that advanced technologies will vastly upgrade the skill requirements of future jobs. Advances in technology are believed to make jobs much more complex and therefore, will require higher level skills in the future. A third view is that the development of new technologies will result in the displacement of massive numbers of workers. The development of robotics and automated processes is viewed as a means to eliminate the human worker from the labor force.

It is true that technology is having a definite effect on the nature and characteristics of the workforce. New occupations are being created while traditional occupations are being changed or eliminated. The workers that fill these changing occupations must update their knowledge and skills to remain employable.

A wider variety of skills are now needed by the workforce. The diversity of occupations has increased to the point where workers must do things that were once performed by many different individuals. Future workers still need to have specific technical skills. However, employers are beginning to want their new employees to have better basic skills. Basic skills enhance workers' abilities to learn new information and techniques and will make the future workforce more adaptable as advances in technology further changes the workplace.

It is evident that technology is having a significant impact on the workforce. However, the true nature of that impact is unclear. Are the above views accurate or are they only myths? The following discussion describes some of the impacts of technology on the workforce and presents the uncertainties that exist regarding the changes that will occur in the future.

The Impact of Technology on Future Occupations

The impact of technology on future occupations is unclear. Will the advances in technology result in more high technology related jobs or will there be an increase in the number of low technology related jobs? The answer to this question is critical to the economic and social well being of this country. To identify the actual impact of technology on future occupations, it is necessary to examine the various views that currently exist.

View 1: Advanced technology jobs are growing at a rapid rate. One view regarding job growth says that technology-related jobs are growing at a significant rate. Based on Bureau of Labor statistics, the fastest growing occupations are in advanced technology areas. As shown in Table 1, eight of the ten fastest growing occupations may be classified as "high technology" occupations (Kutscher, 1987). These fast growing occupations include technicians, engineers, operators, and repairers. As a result of this information, it would appear that advanced technologies will be the primary source of new jobs in the future. In fact, numerous secondary and post-secondary schools are using this information to develop courses in robotics, CAD, CAM, lasers, and computers.

Table 1
Ten Fastest Growing Occupations in Percentage Terms

Occupation	Percent Change	Change in Total Employment	Percent of Total Job Growth
Computer Service Techs.	97	53,000	0.21
Legal Assistants	94	43,000	0.17
Comp. Systems Analysts	85	217,000	0.85
Computer Programmers	77	205,000	0.80
Computer Operators	76	160,000	0.63
Office Machine Repairers	72	40,000	0.16
Physical Therapy Asst.	68	26,000	0.09
Electrical Engineers	65	209,000	0.82
Civil Eng. Technicians	64	23,000	0.09
Peripheral Elect. Operators	64	31,000	0.12

Note: Adapted from "Impact of Technology on Employment in the United States" by R. Kutscher, in *The Future Impact of Technology on Work and Education* (p. 48), G. Burke and R. W. Rumberger (Eds.), 1987, Philadelphia, PA: The Falmer Press, Taylor & Francis.

However, describing job growth in percentage terms does not paint a true picture of the impact of technology on the growth of occupations in the future. A closer examination of Table 1 shows that while the fastest growing occupations are growing at a high rate, they will result in relatively few jobs. For example, the fastest growing occupation in percentage terms is computer service technicians. While this occupation is growing at a fantastic 97% rate, it accounts for less than 1/4th of 1 percent of the total projected job growth. In fact, the ten fastest growing occupations in percentage terms account for less than 4% of the total job growth. Based on this low percentage of the total job growth, technology educators, particularly at the upper secondary and post-secondary levels, must be careful when planning to develop new programs which are oriented towards these "fast growing" advanced technology occupations. It is possible that many of these new jobs will be filled without the need for numerous advanced technology programs. In fact, current data suggests that there are more graduates of advanced technology programs than positions available (Grubb, 1984; Naylor, 1985). Continued growth in enrollments may compound that problem.

View 2: Low tech jobs are growing at a rapid rate. A second view regarding the impact of technology on job growth suggests that advances in technology will result in an increase in low technology-related jobs. This view is in direct contrast to the first view. Based on Bureau of Labor statistics, the fastest growing occupations are not in advanced technology areas. As shown in Table 2, the majority of the ten fastest growing occupations (in absolute terms) are not in advanced technology areas (Kutscher, 1987). For example, the fastest growing occupation in absolute terms is building custodians. While that occupation certainly changes as technology advances, it is not considered a "high tech" occupation. Advanced technology occupations are those that require an in depth knowledge of the theories and principles of science, engineering, and mathematics that underlie technology. This definition includes engineers, scientists, mathematical specialists, engineering and science technicians, and computer specialists (Rumberger & Levin, 1985). Note that while the occupations listed in Table 2 are not growing at a high percentage rate, they do account for a great number of jobs. In fact, these ten fast growing occupations will account for almost 25% of the total job growth in the future.

It is true that advanced technology occupations are growing at a rapid rate although the impact of that growth is less significant because of the small number of actual jobs that are created. One reason for the inability of advanced technology occupations to create a large number of jobs is because of the potential of technology to reduce the need for workers. Automated systems are being developed that are able to reorganize traditional production processes. The change from individual machines to complete manufacturing systems has enabled employers to reduce the number of workers while increasing productivity. For example, the inte-

Table 2
Ten Fastest Growing Occupations in Absolute Terms

Occupation	Percent Change	Change in Total Employment	Percent of Total Job Growth
Building Custodians	27.5	779,000	3.0
Cashiers	47.5	744,000	2.9
Secretaries	29.5	719,000	2.8

General Office Clerks	29.6	696,000	2.7
Sales Clerks	23.5	685,000	2.7
Registered Nurse	48.9	642,000	2.5
Waiter & Waitresses	33.8	562,000	2.2
Teachers	37.4	511,000	2.0
Truck drivers	26.5	425,000	1.7
Nursing Aides & Orderlies	34.5	423,000	1.7

Note: Adapted from "Impact of Technology on Employment in the United States" by R. Kutscher, in *The Future Impact of Technology on Work and Education* (p. 47), G. Burke and R. W. Rumberger (Eds.), 1987, Philadelphia, PA: The Falmer Press, Taylor & Francis, Inc.

gration of a robotic welder into the auto industry replaces two to three human welders and achieves productivity gains that range from 5:1 to as high as 20:1.

Based on the above discussion, it should be clear that technology does impact the total growth of occupations. Advanced technology occupations are growing at a high rate yet they are a small fraction of the total job growth. While low technology occupations are not growing at as fast a rate, they contribute to a greater percentage of total job growth. Because it is possible to interpret job growth in different ways, technology educators must use caution when determining whether or not to emphasize advanced technologies in their curriculum. Clearly, attempting to justify technology education programs that emphasize advanced technologies solely because of high percentage job growth statistics may be a mistake.

The Impact of Technology on Skill Requirements

Technology will also have an impact on the skill requirements needed for *all* jobs at *all* levels (Rumberger, 1984). As occupational skill requirements change as a result of technology, the education and training needed by future and existing workers must also change. However, are the skill requirements increasing or decreasing as a result of the advances in technology? The answer to this question may have a great impact on the content and delivery of technology education programs.

The literature identifies three different views regarding the impact of technology on skill requirements. Each of these views will be examined as they relate to technology education curriculum and instruction.

View 1: Advanced technology creates a wider gap between high skill and low skill jobs. The first view suggests that advances in technology will create a wider gap between the high skill level jobs and the low skill level jobs (Nettle, 1986; Rumberger, 1 984) which may result in a bi-modal distribution of the workforce (Grubb, 1984). Figure 1 graphically shows the potential distribution of occupations based on skill levels if this view is true.

Figure 1. Distribution of worker skill levels.

This view is built on the premise that technology creates a need for highly trained and educated workers to design, develop, and maintain the new technologies. These individuals will require some type of college degree which will increase the need for workers with M.A.'s and Ph.D.'s in technical areas. On the other end of the skill continuum are a great number of low skilled, low paid workers who have little need for training. This bi-modal distribution is thought to be made up of 80% semi skilled or unskilled workers and only 20% highly skilled workers (Nettle, 1986).

View 2: Advanced technology creates jobs at both middle and high skill levels. The second view suggests that advances in technology creates jobs at both the high and middle skill levels (Grubb, 1984). Data collected for high technology and conventional manufacturing sectors in Texas clearly show that the occupational distribution of advanced technology manufacturing is *not* bi-modal. Figure 2 graphically shows the occupational distribution between high technology and conventional manufacturing industries based on 1980 Census data. As suggested in the first view, the need for high skill levels increases as advanced technology is incorporated. However, in contrast to the first view, Figure 2 also shows that the need for middle level skills increases as technology is incorporated.

Figure 2. Manufacturing occupational distribution.
Note: Graph developed from data in "The Bandwagon Once More: Vocational Preparation for High-Tech Occupations" by W. N. Grubb, 1984, *Harvard Educational Review*, *54*, p. 435. Copyright 1984 by President and Fellows of Harvard College.

While the above data is from one state in one primary industry, the data does corroborate with national data from the Bureau of Labor Statistics (Grubb, 1984). Advanced technology sectors do hire more technicians and computer specialists. In addition, the projected growth in middle to high skill level technician jobs are higher in most high tech industries than in conventional industries. This is especially true in the health and information technology fields where more technicians are being used to perform very specific tasks, thus freeing the professional to monitor technicians and to perform other tasks.

As low skill level assemblers are replaced by middle skill level technicians, the amount of training needed to obtain the higher skill level positions will increase. Figure 3 shows the difference in the amount of education needed by the workforce in conventional and high technology manufacturing industries. An increased demand for education at the post-secondary level can be projected as technology is integrated into the private sector.

View 3: Advanced technology decreases the overall skill requirements of the workforce. The third view suggests that advances in technology will actually decrease the overall skill requirements needed by the workforce (Bartel & Lichtenberg, 1987; Faddis, Ashley, & Abram, 1982; Rumberger, 1984, 1987). While the characteristics of future jobs will likely change, the overall skill requirements are expected to decrease. A general assumption

Figure 3. Post-secondary educational levels needed by future workers.
Note: Graph developed from data in "The Bandwagon Once More: Vocational Preparation for High-Tech Occupations" by W. N. Grubb, 1984, *Harvard Educational Review*, *54*, p. 435. Copyright 1984 by President and Fellows of Harvard College.

regarding the impact of technology on skill requirements is that as technology advances, the skills needed to work with technology also increase. This view appears to be developed as a result of interaction with the technological world. For example, many people believe that a computerized word processor is a highly technical tool that is much more complex than the manual or electric typewriters with which they are comfortable. Another example involves the many backyard mechanics who at one time were able to repair their own automobiles. Because of the advances in technology, these mechanically inclined individuals are having considerable difficulty comprehending the new technological systems found in late model vehicles.

As technology advances it certainly appears as though the skill requirements needed to work with those technologies also increase. This statement is only partly true. Research indicates that the impact of technology on worker skill requirements is very different from the general assumption (see Figure 4). While the skill requirements do increase initially, as a technology is further developed and refined, the skill requirements needed to use that technology actually decrease. An example of this phenomenon is the computer. When the computer was originally invented, it was a very complex machine that was difficult to use. Following the development of technologies that lead to the production of transistors and then integrated circuits, the computer became a smaller, more powerful machine that was immensely more complex than the original computer. However, while the computer became much more advanced, it also became more “user friendly.” Refinements in computer technology have led to the development of a machine that is relatively easy to use. The trend to simplify the use of equipment results in a deskilling of the workforce because the technology reduces the need for much of the mental and physical work needed to conduct daily work tasks. Other examples of this deskilling phenomenon can be found in computer programming, automated production, printing, clerical work, and machining.

Figure 4. Impact of technology on worker skills.
Note: Adapted from "The Relationship of Increasing Automation to Skill Requirements" by J. R. Bright, in *Technology and the American Economy*, National Commission on Technology, Automation, and Economic Progress, 1966, Washington, DC: US Government Printing Office.

These three views present differing projections of the impact of technology on the skill requirements of the workforce. First, technology has resulted in a decrease in the skill requirements of some jobs. Second, technology has resulted in an increase in the skill requirements of other jobs. Overall, however, it appears as though there has been little change in the *average* skill requirements of jobs. In a recent study of 200 individual case studies, Flynn (1985) found that while some workers' skill requirements have been upgraded, other workers' skill requirements have been downgraded. It appears as though the overall effect of technology on the skill requirements is small. On an individual basis, however, the effect of technology on skill requirements appears to be quite drastic.

Technology Education's Role in Improving Workforce Productivity

As previously discussed, it is critical that productivity increase in order to regain a competitive advantage in the global marketplace. The problem of increasing productivity is compounded by the ever changing workplace in which a knowledgeable and skilled workforce is needed to adapt to new technological processes. The recent trends in technology and the workplace suggest that the secondary school curriculum needs modification in order to equip students with the knowledge and skills needed to be successful. For example, the most effective and efficient method of preparing the future workforce may no longer include vocational education's traditional emphasis on specific technical job skills. Because of the rapid and complex changes in technological knowledge and skill, the specific technical job skills taught in many secondary vocational programs are obsolete when vocational graduates enter the workforce.

While specific technical job skills will always be needed, they are no longer a sufficient condition for employment.

What role can technology education play in improving the competitive advantage of the United States? A well designed and delivered technology education curriculum will be able to enhance future workforce productivity because it (a) is well suited to reinforce what students have learned in other curricular areas, (b) is ideal for enhancing cognitive process abilities, and (c) promotes active involvement with technology.

Reinforce Academic Content From Other Curricular Areas

A major goal of technology education is to provide students with the knowledge, skills, and attitudes needed to become productive citizens in a highly technological and ever changing society. As a result of the recent advances in technology and the changes that are occurring in the workplace, there should be an increased emphasis on transferable, basic skills. Future workers need to have solid reading, writing, and computational skills. Because technology education offers students the opportunity to learn and apply subject matter from a variety of disciplines in realistic settings, it is well suited to reinforce the general knowledge and skills that are becoming increasingly important. Technology education teachers, by the very nature of their subject matter, incorporate reading, writing, mathematics, science, and social studies content into their courses. By emphasizing generic skills, academic content, and basic technical skills, technology education students will have the opportunity to gain the skills that are needed to keep up with the rapid changes in society and the workplace.

Since 1985, several state and national reports have appeared which suggest what skills and competencies will be needed by the future workforce. These reports have gained a great deal of national attention and seem to be adding fuel to the education reform movement of the 1980s. Because these reports were developed with industry, government, and education involvement, they have the potential to significantly impact the secondary school curriculum.

The state and national workforce projection reports discuss the changes that are occurring in the workplace and identify the skills and competencies needed by the worker of the future. These desired skills and competencies can be summarized into fifteen categories (Johnson, Foster, & Satchwell, 1989).

Figure 5: Summary of workforce competency reports.
Note: From *Sophisticated Technology, the Workforce, and Vocational Education* (p. 33) by S. D. Johnson, W. T. Foster, and R. Satchwell, 1989, Springfield, Illinois: Illinois State Board of Education, Department of Adult, Vocational and Technical Education.

As shown in Figure 5, there is considerable consistency in the recommendations of the workforce projection reports. As one would expect, the basic skills of reading, written and oral communication, and computation are identified by all of the competency reports. As technology advances, the written material used to support new equipment and processes becomes more technical, and therefore, much more difficult to read. As a result, future workers need higher reading and comprehension levels than the present workforce. For example, approximately 70% of the written material used in a cross section of jobs requires *at least* a high school reading level (Mikulecky, 1984) while most technical occupations require at least a 12th grade reading level (McLaughlin, Bennett, & Verity, 1988). The ability to communicate effectively is also essential for productive employment. Workers are being asked to work in teams, deal directly with customers, and participate in decision-making. All of these changes increase the importance of the ability to speak and write effectively.

The worker of the future must also be proficient in basic computational skills which includes working with fractions, decimals, proportions, and measurements. As occupations become more technical, skill with algebra, geometry, statistics, trigonometry, and calculus becomes essential. The importance given to these "academic" skills by the workforce projection reports supports the current trend to increase the integration of the academic and the vocational/technical areas; a trend which has been heavily supported in the technology education movement.

Evidence for the integration of academic content into technology education curricula can be found in each issue of *The Technology Teacher*, the journal of the International Technology Education Association. Each issue of *The Technology Teacher* explicitly presents effective ways to interface the mathematical, scientific, and technological aspects of various technologies. The Council on Technology Teacher Education has also supported the integration of academic content into technology education programs through their annual yearbook (Zuga, 1988). Possibly the best example of the potential for integrating academic content into technology education was provided at *Technology Education Symposium XI*. At this annual symposium, seventeen presenters described their attempts to develop interdisciplinary technology education programs (Erekson & Johnson, 1989). Based on the success of the programs that were described at the symposium, it is clear that technology education is a valid approach for reinforcing basic academic skills.

Enhance Higher Order Thinking Skills

In addition to the academic skills needed by the worker of the future, the workforce projection reports stress the importance of cognitive process skills. Cognitive process skills include the higher order thinking skills of problem solving, decision making, and creativity; skills which lead to flexible behavior and the ability to learn. It is in this area, improving student thinking skills, in which technology education may have the most to contribute. In fact, it has been suggested that improving student problem solving skills should be a major goal of technology education programs (Clark, 1989; Technology Education Advisory Council, 1988; Waetjen, 1989).

Waetjen (1989) observes that many of the recent curriculum guides for technology education identify problem solving as a major teaching method for improving student's understanding of technology and their ability to solve technological problems. While problem solving is viewed in these curriculum documents as a method of teaching, when used properly it also leads to the enhancement of student problem solving abilities. For example, instructors typically solve problems before they are given to students in order to eliminate potential difficulties. As a result, students complete these problems (more appropriately called exercises) with very little cognitive effort. However, creative technology teachers provide their students with ill-structured problems that require the students to actually solve the problems. Students are required to identify the problem, collect information, search for potential solutions, select a solution strategy, and evaluate the result. By actively solving realistic technological problems in technology education courses, students are being forced to think, reason, and make decisions. Through these problem solving activities, students can develop the cognitive skills that are too often neglected in the schools even though they are becoming prerequisites for success in the world of work.

Promote Active Involvement with Technology

While emphasizing academic and cognitive process skills are important goals for a technology education program, they should not be the sole focus. Educational reformers of the 1980s have suggested that employers want graduates to have only strong basic skills and that each business will provide the necessary technical training for their workers (U. S. Department of Education, 1986). However, recent evidence does not support that contention.

Employers still need employees who possess a high level of technical competence. Technical skills are essential because they facilitate the acquisition of additional skills. On a very practical level, when a new technology is adopted by a company, employers tend to involve those workers who have the greatest level of technical skill. For example, when CNC machining is introduced into a factory, it is common for management to select their best machinists to learn the new process. Consequently, technical skills are more important than many education reformers would suggest.

The lack of emphasis given to technical skills in the workforce projection reports suggests that these skills are a “given” for employment. As stated by the Michigan Employability Skills Task Force (1988): “While not specifically addressed in the Employability Skills Profile, the importance of vocational-technical skills should not be overlooked or minimized. The value of specific vocational training will, in addition to the Profile skills, often enhance one's employment opportunities, qualify one for special job classifications, and lead to ultimate success.” (p. 4) As stated by Gray (1989), it seems that what employers mean by basic skills is somewhat different from what academicians mean. In the mind of most academicians, basic skills include reading, writing, and computation. However, there is little doubt that, in the minds of most employers, technical skills are the most basic job competency (Johnson, Foster, & Satchwell, 1989). Because technical skills are a necessity for productive employment, technology education instructors and curriculum developers must continue the industrial arts tradition of hands-on, experiential learning with tools, materials, and systems. Technology education programs may be the only place where secondary level students can experience and interact with technological devices and systems.

While the relationship between technology education curricula and traditional vocational outcomes such as workforce training and productivity have not been actively addressed by the field, technology education does have a unique and significant role to play in the effort to improve workforce productivity. Clearly this role is not to provide the specific vocational and technical skills needed for productive employment. Those skills are best provided through post-secondary programs in community colleges and technical institutes. Technology education can, however, empower its students with a literacy that enhances future learning and interaction with technology, that is, the broad skills and competencies that are most desired by employers. Through hands-on experiences with technology, students can integrate and apply their learning, enhance their higher order thinking skills, and increase their ability to interact with technological devices and systems.

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Curricular Implications for Participative Management in Technology Education

James E. Smallwood

Carl Harshman (1982) believes the United States may be experiencing the most significant change in the work place since the Industrial Revolution. The movement involves a transformation from the traditional, bureaucratic style of management to a more participatory relationship. This new philosophy, known as participative management, attempts to improve the utilization of human resources by involving individual workers in decisions affecting their work.

The growth of participatory and work innovative programs such as quality circles, participative management, and employee involvement has taken place in America since the early 1970s. The concept, which has experienced considerable success in other countries, is currently being implemented in both industrial and non-industrial settings. While only a small fraction of U.S. work places are currently governed by a participative management model, the rate of transformation from a traditional bureaucratic model is accelerating (The Indiana Labor and Management Council [ILMC], 1985). Future indicators predict the trend will continue as we head toward the twenty-first century.

America's Most Valuable Resource

Management is beginning to recognize people as America's most valuable resource, a resource of untapped talent capable of solving problems and making decisions. Involving employees in decision making has become a significant trend in the American work place. Corporations each year spend over $40 billion to train their employees and develop their management staffs (Weischadle & Weischadle, 1987).

The Indiana Labor and Management Council (ILMC) (1985) recently discovered that employee participation increases productivity, work quality, worker satisfaction, employment security, and organizational flexibility. Participation enhances the degree to which a member takes pride in his/her job, and feels a personal responsibility for the outcome of the work.

The development of successful employee involvement requires a basic change in the way people within an organization relate and deal with each other.

James Smallwood is Assistant Professor, Department of Industrial Education and Technology, Morehead State University, Morehead, KY.

Such a change requires all participants to develop the proper cognitive and affective skills and attitudes to contribute in a participative work setting.

A 1985 study by the ILMC revealed that most workers lack the necessary skills to be contributing members in participative work situations. Skills such as problem solving, communications, math and logic, and coping with conflict are but a few of the essential skills identified in the study. The study also revealed that little is being done in the vocational and technical schools in Indiana to prepare students for participative work settings because they do not teach these skills (ILMC, 1985). It is assumed there are many other states in the nation with the same dilemma.

As the change in management philosophy unfolds, it appears something needs to be done in the secondary and post-secondary schools, and colleges and universities in America to better equip students with the proper cognitive and affective skills and attitudes regarding employee involvement.

Implications of Participative Management in Technology Education

Historically, the name of the technology education discipline has changed several times to reflect the direction of the profession. Within the last 25 years the content has also been through some dramatic changes. Digital electronics, CAD/CAM, and robotics are just a few of the content areas being incorporated into technology education programs. One thing that has remained constant throughout the years, however, is where the content is derived. Contemporary technology education programs draw their content from industry and technology, a policy that is unique to the discipline. As technological changes occur, the profession attempts to incorporate these changes into the public school and university programs in order to better prepare students for a constantly changing society. One of the most significant changes currently taking place in both industrial and non-industrial settings is the philosophy toward management of human resources.

In 1982 the New York Stock Exchange did an extensive survey of 49,000 U.S. companies employing 41 million people. The study provided a comprehensive profile of the employee involvement effort taking place in America. The survey described a movement in its developmental stage with enormous potential. Eighty-two percent of the corporations surveyed by the NYSE felt that participative management was a “promising new approach,” compared to three percent who felt it was “just a passing fad” (McKendrick, 1983). The report (New York Stock Exchange [NYSE], 1982) recommended improved workforce productivity through educational programs in secondary schools, better training of young managers, and more employee involvement in decision making and financial gain sharing.

The Carnegie Report recommends a study of technology by all students. Ernest L. Boyer, president of the Carnegie Foundation for the Advancement of Teaching, has this to say:

> We can and must help every student learn about the technology revolution, which will dramatically shape the lives of every student. And it's here that the industrial arts educator has a crucial role to play. (American Industrial Arts Association, 1985)

Technology education is faced with an opportunity to prepare students for participative work settings and should incorporate this into the existing curriculum.

Purpose of the Study

The purpose of this study was to identify and validate a list of worker characteristics necessary for participative management. These cognitive and affective skills can be used in planning, organizing, and developing technology education programs to prepare students to be contributing members in work-group situations. The study validated worker characteristics in order of importance as perceived by selected industrial personnel. Therefore, in planning curriculum, emphasis can be placed on those characteristics from highest to lowest priority. The primary objectives of the study were to:

1. provide information on worker characteristics in industrial participative management to be used in planning, organizing, and developing technology education programs;
2. provide information to determine whether current technology education programs are preparing students for participative work settings;
3. better inform technology education teachers and curriculum developers of the participative management philosophy;
4. provide information that can be used to better prepare students with the cognitive and affective skills and attitudes for participation.

Methodology

A survey was conducted of 38 randomly selected industrial personnel, who function as training directors, employee involvement coordinators, and others interested in the participative management concept. The participants were chosen from a data base of members in the Association for Quality and Participation (AQP), formerly the International Association of Quality Circles. The assumption was that since this group was so close to the training process they could provide the most accurate data. The members of the sample group were employed by companies ranging in size from 150 to 13,000 employees.

The Delphi process was the research technique used to gather the necessary data. The opinions of the group were solicited three times, through survey instruments, in order to arrive at a group consensus. The three-round process was used in anticipation that each round would further refine the list and validate the data.

The initial data collection instrument included a list of worker characteristics for industrial participative management, constructed on the basis of a review of literature and research, and consultation with specialists involved in work innovative programs. Faculty members from the School of Business, School of Education, and School of Technology at Indiana State University involved in teaching the participation concept were also asked for assistance.

In the process of developing the instrument, doctoral students in curriculum and instruction and selected faculty members at Indiana State University were asked to review the initial draft to assure clarity of items and instructions. For further clarity, accuracy, and validation the instrument was then submitted to a small group of training directors involved in employee involvement programs for their review.

A coefficient of correlation was used to determine the reliability between responses on the first and second round instruments. When tested, using a t-test, all the responses proved to be significantly different from zero at the .05 level of probability. A high positive correlation between the first and second round instruments was revealed by the analysis.

The Delphi technique for collecting the data took place over approximately a five month period. The initial data collection instrument for round one included a section for collecting demographic information about the sample group and the company. It also included a section addressing research questions one and two regarding worker characteristics necessary in preparing someone to become a contributing member in a participative work setting. The section pertaining to research questions one and two was a list of worker characteristics which the participants were asked to evaluate by a five-point rating scale ranging from non-essential to essential. They also had an opportunity to list other characteristics believed to be important to the participative management concept.

The data from round one were collected and compiled in order to prepare the round two instrument. The round two instrument was designed to further validate the worker characteristics as well as gather information to answer research questions three and four. Research questions three and four pertained to those characteristics industrial personnel teach their employees and which should be taught in a technology education curriculum.

Once again, the data were collected and compiled to prepare the final instrument. The round three instrument was a rank ordering of worker characteristics along with the group mean for each one. The respondents were asked to review the list for validation. The instrument was also designed to gather additional information in answering research question four.

Of the 38 subjects who agreed to participate in the study, 28 completed all three instruments.

Results

The analysis of demographic data revealed a changing managerial philosophy from a directed (autocratic) approach to a group participatory approach. In all, 51.5% of the companies surveyed have transformed from a directed to a group participatory or delegated management philosophy within the last five years.

All but one of the companies surveyed had established employee participation groups within the last ten years. Ninety-four percent of the respondents anticipate a growth in the number of employee participation groups for their respective companies during the next two years.

Some of the reasons for electing to implement the participation concept were to: (1) improve communications, (2) improve product quality, (3) reduce costs, (4) improve employee relations, (5) become more competitive by increasing production, and (6) tap the unused potential of all employees.

In regard to worker characteristics for participative management, problem solving and communication skills were considered the most important by the sample group. The top 25 worker characteristics are listed in Table 1. These characteristics are listed in order of importance from one to twenty-five. Eleven of the first thirteen worker characteristics were directly related to problem solving and communication skills.

Other characteristics considered extremely important were team building, gathering, analyzing, and presenting data, group process, and goal setting.

Those characteristics related to problem-solving are the primary concern of industrial trainers preparing someone to participate in a work-group situation. Five characteristics, all relating to problem-solving, were taught by all the companies surveyed on the second round instrument. The characteristics were problem-solving, gathering information, identifying and selecting problem causes, generating problem solutions, and evaluating problem solutions.

Table 1
Worker Characteristics Important to the Participative Management Concept

1.	Brainstorming	14.	Group Process
2.	Problem Solving Skills	15.	Goal Setting
3.	Identifying and Selecting Problem Causes	16.	Implementing Change
4.	Evaluating Problem Solutions	17.	Recognizing and Dealing with Verbal Comm. Problems
5.	Generating Problem Solutions	18.	Coping with Conflict
6.	Communication Skills	19.	Motivation
7.	Team Building	20.	Patience/Perseverance
8.	Gathering, Analyzing, and Presenting Data	21.	Group Dynamics
9.	Perception and Listening	22.	Leadership Ability

10.	Verbal Communication	23.	Desire/Commitment
11.	Identifying and Analyzing Problems	24.	Consensus Decision Making
12.	Gathering Information	25.	Negotiation (Strive for win-win)
13.	Displaying/Organizing and Analyzing Information		

In addition, group process, group dynamics, team building, leadership ability, communication skills, identifying and analyzing problems, displaying/organizing and analyzing information, gathering, analyzing, and presenting data, and brainstorming were taught by at least 85% of the companies surveyed.

Research question 4 was asked to find out which of these worker characteristics the sample group would like to see taught in a technology education curriculum. There were very few differences between those characteristics believed to be most important and what should be taught. The top 25 worker characteristics were the same as those in Table 1 with the exception of project planning and oral presentation, replacing patience/perseverance, and desire/commitment.

Curriculum Development for Participative Management

Curriculum development for participative management in technology education programs is almost non-existent. There are three primary reasons for this neglect.

1. The concept of participative management in America is still in its infancy stage. Although the concept itself has been practiced since the early 1970s it has just recently been manifested as a viable technique for improving many aspects of the work setting.
2. Many technology education teachers are unaware of the concept and those aware of it aren't sure what should be taught.
3. Little has been done to identify necessary worker characteristics (cognitive and affective skills) to aid in planning, organizing, and developing curriculum.

The relationship of the first two problems is evident. Technology education teachers appear to be unaware of the concept partly because it is so new and partly because it is unaddressed in the textbooks and professional journals.

A review of selected manufacturing and general technology textbooks available for industrial arts/technology education teachers revealed a serious neglect of the participative management concept. Nearly all of the reviewed textbooks, published within the last ten years, were concerned with authority administered from the top down. There was little mention of the changing philosophy toward employee involvement.

Many of the textbooks discussed problem-solving techniques, the brainstorming process, quality assurance, and statistical process control, all of which are considered relevant to the concept of participation. *Technology: Today and Tomorrow* discussed quality circles and statistical process control. *Living With Technology* dealt with quality circles and problem solving techniques. *Exploring Manufacturing*, and *Modern Industry* both discussed line and staff management. Neither *Manufacturing Processes* or *Processes of Manufacturing* made reference to involving employees in decision making. *Technology: Today and Tomorrow*, and *Living with Technology*, were the only textbooks reviewed which made specific reference to the concept of employee involvement.

A review of the professional journals for technology education such as *The Technology Teacher*, *Industrial Education*, and *School Shop* also revealed little on the topic of participation.

A few articles discussed the success of the Japanese in becoming an industrial power due to their technique of employee involvement and participation. Dillon (1984) wrote about Japanese methods for increased productivity and what American industry might learn. Sullivan (1988) discussed a quality control module for technology education with reference to quality circles and the concept of participative management.

Articles regarding the factories of the future (Walden, 1988), and meeting the employment needs in the eighties and beyond (Peckham, 1988) did make reference to the idea of involving employees in decision making. For the most part, however, the review of these particular journals over the past ten years revealed very little regarding the changing managerial philosophy.

The third point regarding worker characteristics for participation was addressed in this study. It has been discussed by a few other researchers, including the work of Little (1986), ILMC (1985), Sedam (1983), Lloyd and Rehg (1983), and Reeves (1983).

Curricular Materials and Techniques

Many businesses, industries, and consulting firms have developed training programs and materials to teach the proper skills for participation. Materials and techniques identified by several authors for use in industrial training include: histograms, graphs, control charts, flow charts, Pareto analysis, brainstorming, cause-and-effect diagrams, check sheets, decision matrices, presentation techniques, prioritizing techniques, and cost-benefit analysis (Ball, 1982; Lloyd & Rehg, 1983; Reeves, 1983; Sullivan, 1988; Torrence, 1982; and Weischadle & Weischadle, 1987). The basic quality circle problem-solving process includes: problem identification, define the problem, investigate the problem, problem analysis, choosing a solution, presentation to management, and implementation.

Most of the training materials and techniques for participative management have been developed by consulting firms or by the company that wishes to incorporate the concept. Business now runs what may be the largest educational system in the country. Weischadle and Weischadle (1987) point out that training and development costs in business now approach the total annual expenditure of all of America's four-year and graduate colleges and universities.

Very little has been done in vocational education or industrial arts/technology education programs in regard to participative management curriculum development. One of the conclusions drawn from the ILMC (1985) study was that very little is currently being done to prepare students for participatory programs. However, participatory approaches are relatively new to business and industry in this country and it is not surprising that schools have not yet developed curricula in this area (p.38).

Although very little has been done regarding participative management curriculum development, many of the important characteristics are being taught at various places in the technology education curriculum. Characteristics such as problem solving, communication skills, team building, group process, and many others are incorporated in technology education classes. These skills are extremely important to the concept of participative management and it might be a good idea to label them as such when they are included in various curricula.

Summary

Based on the findings of this study, the concept of participative management is expected to grow in industrial organizations over the next few years. The worker characteristics identified can be used in planning, organizing, and developing technology education programs to prepare students to be contributing members in work-group situations.

As technological changes occur, the profession has made a gallant effort to incorporate these changes into public school and university programs. As if new technologies such as robotics, CAD/CAM, lasers, and superconductivity are not enough, the profession is faced with yet another challenge, the changing philosophy toward management of human resources.

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Technology Teacher Education Curriculum Courses

Karen F. Zuga

As the shift from industrial arts to technology education takes place, there is a tendency to merely change the name of a course and not to change the course content. In order to make the change to a technology education curriculum teachers need to be able to conceptualize and design new courses.

One of the intervention strategies for increasing the likelihood of renewal and improvement in technology education has been through teacher education programs and curriculum courses for preservice technology teachers. Most preservice teachers study curriculum development with respect to industrial arts/technology education, yet, evidence of what they study about curriculum is lacking.

Although recent publications in the field of curriculum have focused on the variety of ways in which educators design curriculum (Eisner, 1979; Eisner & Vallance, 1974; Joyce, 1980; McNeil, 1977; Ornstein & Hunkins, 1988; Saylor, Alexander, & Lewis, 1981; Schubert, 1986; Wiles & Bondi, 1984), few have examined the ways in which technology educators design curriculum or teach preservice teachers to design curriculum. The literature of the field reveals few studies of what is actually taught to future technology teachers in curriculum planning courses. How teachers are taught to plan curriculum may very well influence their ability to implement curriculum change in technology education.

Informal discussions with practicing teachers often reveal difficulties and guilt associated with designing curriculum. The difficulties and guilt stem from an inability to implement the kind of curriculum design process which was taught in the preservice program. Recently, a teacher working with this project revealed that during a departmental meeting his colleagues decided that they wrote curriculum with a "backwards" approach since their curriculum planning practices did not resemble what had been taught to them in their preservice courses. This very practical problem, and the lack of knowledge concerning contemporary curriculum courses, brings up the question, what is being taught to preservice technology education teachers about curriculum planning?

Karen Zuga is Assistant Professor, Industrial Technology Education Department, The Ohio State University, Columbus, Ohio. This project was the result of a grant from the Office of Vocational and Adult Education, U. S. Department of Education. However, the opinions expressed herein do not necessarily reflect the position or policy of the U. S. Department of Education, and no official endorsement by the U. S. Department of Education should be inferred.

Objectives and Questions of the Study

Based upon the very real problem that teachers have with curriculum design I sought to identify and describe some of the practices and goals of technology teacher education curriculum courses. Since research can be a tool for change I hope that this study supports a dialog about the role and responsibility of teacher educators with respect to changing curriculum practices in the field. Based on these objectives, the following questions guided the study:

1. What is the context of curriculum courses for preservice technology teachers?
2. What is the content and practice (as described by teacher educators) of curriculum courses for preservice technology teachers?
3. What curriculum course goals do teacher educators prefer?

Methods

As a primarily descriptive exercise, I employed a survey in order to collect data and information about preservice curriculum courses in technology teacher education. The survey included a combination of forced-choice and open-ended questions. Although the open-ended questions were thought to be difficult and did turn out to cause some response problems, open-ended questions were chosen in order to avoid researcher bias by preliminary categorization of concepts.

The survey was sent to the population of 214 department chairpersons identified in the 1988-1989 *Industrial Teacher Education Directory* which could have a teacher education program in technology education. The response rate to the survey was 51% or 109 responses. In addition it should be noted that 23% of the returned surveys were not potentially useful due to a lack of a technology teacher education program at the institution, a phenomenon which could have influenced the number of returned responses. The number of potentially useful surveys was further reduced by the courses offered within the teacher education programs. Of the 84 surveys returned with a teacher education program indicated, only 59 (70% of the useful surveys) of the programs included curriculum courses. The other programs either included a combined methods and curriculum course or required no curriculum courses. The objective of the study was to identify curriculum practices and beliefs of technology teacher educators, therefore, I chose to analyze only the surveys from the 59 programs that included a curriculum course.

Since I was conducting the study for a preliminary description of practices in technology teacher education curriculum courses and to identify as many practices as possible, the data are minimally reduced into categories in this report. I decided to limit the categorization in order to provide the reader with as much evidence as practical so that the reader could use the data for the purpose of agreeing or disagreeing with interpretation in this paper and to maintain fidelity to the concepts of the respondents.

Results

Based on the questions posed for the study three categories of information are reported. These three categories include information about the curriculum courses offered, practices in the curriculum courses, and teacher educators' attitudes about curriculum design.

Course Description

Information about the curriculum courses offered was obtained in order to briefly describe the context of the curriculum courses so that some understanding of the participants and programs could be conveyed. Therefore, questions about the program name, courses offered, length of courses, credits, and students in the courses were asked.

Of the surveyed program areas that offered curriculum courses for and certified technology education teachers, 34% of the programs were listed as technology education programs. The remaining programs used a wide variety of titles which could be grouped in the following categories: industrial education (20%), industrial technology/education (15%), industrial arts/education (15%), industrial science/studies/etc. (12%), and vocational-technical education (2%). Further condensing of the categories into one that includes all programs using the modifier "industrial" in the title reveals that 62% of the programs are designated as some form of industrial study.

Most of the programs (56%, n=33) offered one curriculum course. Two courses were offered in 31% (n=18)of the programs and the remaining programs offered three or more courses. Course length was determined by the quarter and semester system with 56% (n=33) of the programs offered in the semester system. Most of the courses (70%, n=41) were offered as three credits with the remaining courses offered in a range of two to six credits. Forty-two percent of the courses were taught

Table 1
Program Titles

Title	n	%
Technology Education	20	34
Industrial Education	12	20
Industrial Technology/Education	9	15
Industrial Arts/Education	9	15
Industrial Science/Studies/Etc.	7	12
Vocational-Technical Education	1	2
Missing	1	2

within the technology teacher education program area, 34% of the courses were taught within the department, two percent of the courses were taught within the college, and 22% of the courses were taught by a combination of program, department, and college faculty.

Table 2
Administrative Unit Responsible for Teaching Curriculum Courses

Administrative Unit	n	%
Program Area	25	42
Department	20	34
Combination (Program Area and Department)	13	22
College	1	2

Student enrollment in the curriculum courses by major was a particularly interesting question which related directly to the impetus for the study. Recent trends of low student enrollment in technology education, an historical association with vocational education, and the distribution of responsibility for teaching curriculum courses prompted a question about the majors of the students enrolled in curriculum courses. A little over half of the curriculum courses (56%, n=33) were offered exclusively to technology education majors. In the remaining courses a combination of vocational education, training, and general education students were also in the same courses. Vocational education majors were the most frequent students to be combined with technology education students with 39% (n=23) of the classes enrolling both vocational education and technology education majors. Training majors were in 15% (n=9) of the courses and only two percent of the courses enrolled general education majors.

Course Practices

Analysis of the practices within curriculum courses focused on the assigned texts and materials, course goals, course topics, and student assignments. All of this information was elicited with open-ended questions.

Course texts and materials. Table 3 presents an overview of the types of materials and texts used in technology teacher education curriculum courses.

Table 3
Format of Course Materials

Material	n	%
Textbooks	55	93
Selected Readings and Handouts	20	34
Curriculum Guides	14	24
Vendors' Catalogs	01	01
No Response	01	01

* Columns will not total to 59 or 100% due to the use of several formats in one course

The most frequently used materials were texts. Selected readings and national, state, and local curriculum guides followed in frequency of use. Because texts can play an important role in defining a curriculum perspective, the titles and content of the texts were analyzed in order to identify the primary audience for the book. The majority of the texts were written for industrial education audiences and included information about curriculum development for vocational educators and industrial trainers. Representative texts in each category, with the frequency of use included, are shown in Table 3A.

Table 3A
Selected Examples of Textbook Used in Curriculum Courses

Textbook	n
Industrial Education	
Giachino, J. W., & Gallington, R. O. (1961). *Course construction in industrial arts and vocational education*. Chicago: American Technical Society.	6
Miller, W. R., & Rose, H. C. (1975). *Instructors and their jobs*. Chicago: American Technical Society.	5
Bartel, C. R. (1976). *Instructional analysis and materials development*. Chicago: American Technical Society.	4
Andrews, R. C., & Ericson, E. E. (1976). *Teaching industrial education: Principles and practices*. Peoria, IL: C. A. Bennett.	3

Table 3A (cont.)

Finch, C. R., & Crunkilton, J. R. (1979). *Curriculum development in vocational and technical education: Planning, content, and implementation*. Boston: Allyn & Bacon.	3
Paulter, A. (1978). *Teaching technical subjects in education and industry*.	2
Silvius, G. H., & Bohn, R. C. (1976). *Planning and organizing instruction*. Bloomington, IL: McKnight.	2
Bott, P. A. (1987). *Teaching your occupation to others: A guide to surviving your first year*. Elmsford, NY: National.	2
Baird, R. J. (1972). *Contemporary industrial teaching: Solving everyday problems*. South Holland, IL: Goodheart-Willcox.	1
Center on Education and Training (1989). *Performance based teacher education module series*. Athens, GA: American Association for Training and Employment.	1
Bollinger, E. W., & Weaver, G. G. (1955). *Trade analysis and course organization for shop teachers*. New York: Pitman.	1
Fryklund, V. C. (1965). *Analysis techniques for instructors*. Milwaukee, WI: Bruce.	1
Mager, R. F., & Beach, K. M. (1967). *Developing vocational instruction*. Fearon.	1
McMahon, G. G. (1972). *Curriculum development in trade and industrial and technical education*. Columbus, OH: Merrill.	1
Industrial Arts/Technology Education	
Unspecified ACIATE/CTTE Yearbooks	5
Technical Foundation of America. (undated). *Industry and technology education: A guide for curriculum designers, implementors, and teachers*.	3
American Industrial Arts Association (1985). *Standards for technology education programs*. South Holland, IL: Goodheart-Willcox.	1
Kemp, W. H., & Schwaller, A. E. (Eds.) (1988). *Instructional strategies for technology education*. Bloomington, IL: McKnight.	1
Maley, D. (1973). *The Maryland plan*. New York: Bruce.	1
Maley, D. (1978). *The industrial arts teacher's handbook: Techniques, principles, and methods*. Boston: Allyn & Bacon.	1
Martin, G. E. (1979). *Industrial arts education: Retrospect, prospect*. Bloomington, IL: McKnight.	1
Snyder, J. F., & Hales, J. A. (1981). *Jackson's Mill industrial arts curriculum theory*. Charleston, WV: West Virginia State Department of Education.	1
General Education	
Mager, R. F. (1984). *Preparing instructional objectives*. Belmont, CA: Lake Management & Training.	3
Kim, E. C., & Kellough, R. D. (1983). *A resource guide for secondary school teaching: Planning for competence*. New York: Macmillan.	1
Oliva, P. F. (1982). *Developing the curriculum*. Boston: Little, Brown.	1
Orlich, D. C. et al. (1985). *Teaching strategies: A guide to better instruction*. Lexington, MA: Heath.	1
Wulf, K., & Schave, B. (1984). *Curriculum design: A handbook for educators*. Glenview, IL: Scott, Foresman.	
State of Ohio. *Course of study development: A process model*. Columbus, OH: Ohio Department of Education.	1

Of the technology education texts listed, few could be classified as curriculum textbooks as contrasted with either industrial education or general education texts. This may be due to the lack of curriculum textbooks for the small technology teacher education market. The use of the ACIATE/CTTE yearbook series appears to attempt to remedy this.

Table 4
Curriculum Course Goals

Goal	n*	%*
Develop a course of study, course materials, sequence of content	37	63
Know the procedures of content selection or analysis of subject matter	30	51
Know the relationship of philosophy to objectives	21	36
Formulate objectives or outcomes	10	17
Determine the needs of students	7	12
Evaluate courses	6	10
Present materials	4	7
Analyze materials	3	5
Prepare for first year of teaching	2	3
Reconstruct and improve a way of life	2	3
Integrate subject matter	2	3
Understand taxonomies	2	3
Transmit the cultural heritage	1	2
Describe difficulties of curriculum change	1	2
Use problem solving and inquiry	1	2
Promote leadership and professionalism	1	2
Know state requirements	1	2
Plan facilities	1	2

* Columns will not total to 59 or 100% due to use of several types of goals in each course

Course goals. Respondents were asked to list the three most important curriculum course goals. A varying number of goals were reported by each respondent. Seven of the surveys did not have this information. The primary goals found in technology teacher education curriculum courses as reported in Table 4 are to select content and to develop courses.

Course topics. Course topics are reported here in Table 5 as a frequency list that is rank ordered. The topics in technology teacher education curriculum courses focus on analyzing and selecting course content and appear to be related to the course goals.

Table 5

Course Topics

Topic	n*	%*
Selecting and organizing content, knowledge, learning, etc.	53	90
Philosophy and goals	36	61
Structure of knowledge	36	61
Program and student evaluation	23	39
Formulating objectives	22	37
Procedures, such as teaching methods, discipline, text selection, etc.	19	32
Organization, management, and supervision	10	15
Social foundations	7	12
Occupational/task analysis	5	8
Professionalism	4	7
Resources	4	7
Research	2	5
Change	2	5
Teacher certification testing	2	5

* Columns will not total 59 or 100% due to use of several topics in each course

Student assignments. To complete the description of the activities within the courses as reported by the respondents, types of student assignments with the frequency of use are listed in Table 6.

Course goals, topics, and student assignment lists and frequencies appear to be related, demonstrating some unity of purpose and execution.

Teacher Educators' Attitudes

Two questions which assessed teacher educators' attitudes about curriculum courses were asked. The definition of curriculum used in the course was requested as a means of identifying beliefs about curriculum and a rating scale was used to indicate what topics would be important in a curriculum course.

Curriculum definitions. Respondents were asked to list the definition of curriculum that was used in the course. Of the surveys returned, 48 respondents answered this question. Each definition was categorized to fit into one of five major views of curriculum. A few respondents included more than one definition which they used for the purpose of comparison. The major emphases of definitions are reported in Table 7

Table 6
Student Assignment

Assignment	n*	%*
Develop a course	34	58
Develop lesson plans and instructional materials	25	42
Write performance objectives	18	31
Study foundations, philosophy, etc.	12	20
Create an evaluation plan	8	14
Evaluate a course	7	12
Perform a task analysis	7	12
Reading and research	6	10
Perform a needs assessment	2	3
Teach	2	3
Develop a program for a school	2	3
Create a concept map	1	2
Define curriculum	1	2
Study methods	1	2
Write a career intent paper	1	2
Plan for an advisory committee	1	2
Create a planning guide for a unit	1	2
Take field trips to school laboratories	1	2
Select equipment and materials	1	2

* Columns will not total 59 or 100% due to use of several types of assignments

Table 7
Composite Curriculum Definitions Used

Definition	n	%
The process of arranging content for the purpose of teaching	21	36
A course of study involving arrangement of subject matter	18	31
All of the activities of the school in which students are engaged	4	7
There are several definitions used for the purpose of comparison	3	5
Analysis of community needs, subject matter, and the environment	2	3
Missing	11	17

The definitions of curriculum used in the technology teacher education curriculum courses reflect the pattern which evolved in the lists of course goals, topics, and student assignment.

Content focus. The respondents were asked to indicate, on a simple rating scale, agreement or disagreement with several statements about the focus of curriculum courses for technology education majors. A four-point scale was used with a rating of one representing the greatest amount of agreement. The content foci of curriculum courses, rank ordered by mean rating of agreement, are presented in Table 8.

Table 8
Teacher Educators' Attitudes About Content Foci for Curriculum Courses

Focus	mean	sd
Plan activities based upon critical thinking and problem solving skills	1.10	.42
Identify and organize subject matter concepts for course outlines and lessons	1.14	.54
Write performance objectives	1.37	.72
Plan activities which engage learners in socially relevant projects	1.54	.77
Perform systems analysis	1.65	.81
Work with each learner in order to identify and integrate personal interests	1.73	.82
Create taxonomies of subject matter	1.97	1.11
Perform job and task analysis	2.11	1.20

Some variation in the pattern of identifying and organizing subject matter as the major emphasis in curriculum courses appears in the survey of teacher education attitudes. For example, planning activities based upon critical thinking and problem solving skills did not appear as the major emphasis in previous tables.

Discussion

As an initial survey of technology teacher education curriculum course practices the data presented here can initiate a discussion about the process of preparing teachers. Certainly, the information could be useful for the planning of curriculum courses for preservice technology teachers.

At present, it appears as though the majority of the respondents teach with similar goals, topics, and student assignments. In the majority of the cases these goals, topics, and student assignments form a pattern of content which focuses on selection of content and course development. Due to this focus, the majority of the courses appear to be very technical in nature. By technical I mean that the processes of analyzing, selecting, and organizing content take precedence over the broad philosophical questions about what knowledge is of most value (Cherryholmes, 1988). In addition, goals such as integrating subject matter, understanding taxonomies, and reconstructing and improving a way of life (which may relate to addressing the general education nature of technology education and topics such as studying foundations, reading, and research), and creating a concept map (which may enable technology teachers to design curriculum for general education purposes) are not listed as frequently as the technical activities pertaining to course development.

There are other disturbing trends in the information about the context of the courses and the materials and textbooks which are used. Over 54% of the textbooks used are designed primarily for industrial education and 44% of the courses were offered for a combination of technology, vocational, and training majors. Vocational educators and trainers have a clear mission of identifying the essential tasks of a job or trade, organizing those tasks for instruction, and doing their best to prepare their students to be competent on a job. Given that task, vocational educators and trainers have developed some of the most sophisticated systems for creating curriculum, and their curriculum planning processes are effective for their purposes. One has to question, however, if these same systems are effective for technology education (Lux, 1979). Why would a technology educator who wishes to deal with a broad array of general education goals want to use a curriculum planning process that is designed to effectively and efficiently identify course content aimed at preparing students to meet occupational requirements? Over half of the textbooks listed on the survey are designed for industrial education and include curriculum planning processes for vocational educators and trainers.

Moreover, the age of the industrial education texts is questionable. The publication dates on texts used and reported by respondents range from 1955 to 1979. One might say that the process of identifying appropriate curriculum was as valid in 1955 as it is today, but current literature about curriculum, especially curriculum for general education, cannot be included in texts from the 1950s.

Those who do not use texts designed for industrial education have chosen to use either general educational texts or a range of books which provide examples for technology education or deal with technology education issues. The very real problem is that there is a lack of books about technology teacher education topics such as curriculum design. The response by a few teacher educators may have been to forgo the vocational oriented texts in favor of selected reading, teacher made materials, and state department documents.

Adding to the frustration of not having adequate texts, is the very real financial exigency that forces teacher education programs to place both technology education majors with trade and industry majors and training majors in curriculum development courses. Each target population has different curriculum design concerns starting with the fact that they deal with different student populations in their respective schools and organizations and have different purposes when teaching those students. A potential outcome of this practice is confusion and dissatisfaction for the prospective teacher. A course taught with an even allocation of information for each group may result in a loss of time devoted to the teacher education majors' primary interests and in hearing much useless or confusing information which is not relevant to future teaching practice.

In addition to the need to question curriculum course practices and texts is the discrepancy in teacher educators attitudes about the content focus of curriculum courses. While the majority of teacher educators responding to the survey indicated that the processes of arranging content and a course of study were the definition of curriculum that they used, the content focus for curriculum courses which had the most agreement among respondents was planning activities based upon critical thinking and problem solving skills. The majority of goals, topics, and student activities listed in the survey did not relate to this focus. In a sense, the focus on planning activities validates the “backwards” approach that concerned the teacher who assisted in the project. Perhaps, technology teacher educators are providing mixed messages to preservice teachers through their attitudes.

Summary

While a coherent pattern of goals, topics, and student assignments appear to exist in technology teacher education courses this pattern reveals a technical orientation to developing curriculum. Combined with the persistent influence of vocational purpose through texts and the practice of grouping industrial education students majoring in technology education, vocational education, and training into curriculum courses, preservice technology teachers may be getting a confusing message, at best, about appropriate curriculum design processes for technology education.

This study of technology teacher education curriculum courses reveals the following points:

1. Curriculum instruction in technology teacher education has a limited (and often no) number of goals for the study of curriculum.
2. The age of the curriculum texts in use (as reported by the respondents) dates the information.
3. Industrial education books which are based in vocational education curriculum planning methods are predominant.
4. The practice of combining technology education majors with industrial education majors predominates.

Due to the low return of the survey recommendations for action would be questionable; further study is needed. However, the preliminary results need not stop those who are providing technology teacher certification programs from examining their own practices. They should consider the long term effects on technology education reform of combining dissimilar majors, the quality and recency of the texts, and their own curriculum knowledge base. In order to revise technology education, technology teachers must have the best possible information.

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Book Review

Toward a Philosophical Technology Education

Ferré, Frederick. (1988). *Philosophy of technology*. Englewood Cliffs, NJ: Prentice Hall, $17.33 (paperback), 147 pp. (ISBN 0-13-662586-X)

Reviewed by Carl Mitcham

Technology has increasing impacts on society and applications in education. Technology education, as a distinct area of study in K-12 schools, is slowly gaining a recognized place in the school curriculum that reflects the importance of these impacts. But what is the application of philosophy to technology? This brief textbook introduction to the philosophy of technology in the highly respected Prentice Hall "Foundations of Philosophy Series" — concerned, as it is, with what education in its deepest sense has to say about technology — provides an excellent starting place for addressing this question.

The text opens with an overview of philosophy as "the sustained effort at wondering critically about . . . comprehensive issues" (p. 2) applied to technology. What constitutes technological knowledge (as distinct from, say, scientific knowledge)? What is the relation between technology and human values. How are technologically constructed objects (artifacts) different from natural objects?

Such questions point readily to a need to define technology. Chapter two constitutes a stimulating consideration of a number of key questions related to the concept of technology. Must technology always be material? Is it always science-based? Can animals have technologies? Is technology natural or unnatural? Developing a definition that steers a middle course between the Scylla of excessive narrowness and the Charybdis of over generality, Ferré defines technology as "practical implementations of intelligence" (p. 26). Building on this definition chapter three goes into greater detail to examine technology as the practical implementation of practical intelligence (craft), while chapter four describes that peculiarly modern form of technology which is the practical implementation of theoretical intelligence (science).

Carl Mitcham is Associate Professor, Science, Technology, and Society Program, The Pennsylvania State University, University Park, Pennsylvania.

The first four chapters of the text thus deal with definitional and epistemological issues. The next four turn to questions of life and the problems of living with technology. Chapter five, considering general issues of "technology and modern existence," contrasts the "bright visions" of Karl Marx and Buckminster Fuller with the "somber visions" of Martin Heidegger and Herbert Marcuse. Chapter six focuses on the ethical assessment of technology, mentioning specifically the moral problems that arise in conjunction with workplace automation, computers, nuclear energy, Third World development, and genetic engineering.

It is unfortunate that questions of education and technology are not directly broached in chapter six, but each of the five specific areas of ethical concern certainly has implications for both the utilization of educational technologies and instruction in and about technology in the schools. Classroom automation constitutes a kind of workplace automation that can be used to deskill teachers. Computers can be the basis for invasions of privacy of and by both teachers and students. The risks of nuclear war and nuclear power generation come home in direct ways to the schools (remember the nuclear civil defense drills from the 1950s and some recent debates about siting schools near nuclear power plants). Technological development and education can raise issues of justice and equity for minority students as much as for Third World countries. Genetic engineering has implications for the kinds of students and teachers — and, indeed, for the kind of education — that will take place in the future.

The last two chapters consider debates about the mutual influences between technology and religion, and technology and metaphysics, respectively. The concluding discussions of technological models of human nature and free will versus technological determinism have direct bearing upon the theory and practice of education in the most general sense, and can provide the foundations for developing guidelines for assessing the appropriateness of technologies to different educational contexts.

Although the relation between education and technology is never directly addressed, this book provides reflective background for the informed development of a philosophy of technology education. This in turn can help us move from the technological transformation of education toward the educational transformation of technology. °

Editorial

The Integration of Science, Technology, and Mathematics Myth or Dream?

Gene W. Gloeckner

The achievement level of U.S. science students does not compare favorably with other countries. According to the National Science Foundation (NSF), the United States ranked 8th out of 15 countries on a 5th grade science achievement test. However, by the 9th grade, students in the United States ranked 15th out of 16 countries rated.

As students enter high school, achievement continues to be low in all areas of science. Physics students ranked tenth among 14 countries rated. In biology, the U.S. ranked 14th out of 14 countries (NSB, 1987).

Table 1
Ranking of U.S. Students in Science

Grade	Subject	Rank	Number of Countries Ranked
5th	Science	8th	15
9th	Science	15th	16
High School	Physics	10th	14
High School	Chemistry	12th	14
High School	Biology	14th	14

The low U.S. student performance may be related to the time spent on task. According to the National Science Teachers Association (NSTA Report, April 1989), high school students spend far less time in science courses than their counterparts in the Soviet Union and the People's Republic of China.

Gene Gloeckner is Associate Professor, Department of Industrial Sciences, Colorado State University, Fort Collins, Colorado.

Technology education can provide an integrated methodology for science and increase the time on task of our students in science and technology.

Table 2
Time Spent on Biology, Chemistry, and Physics

	U.S.	USSR	PR China
Biology	180 hrs. 1 year	321 hrs. 6 years	256 hrs. 4 years
Chemistry	180 hrs. 1 year	323 hrs. 4 years	372 hrs. 4 years
Physics	180 hrs. 1 year	492 hrs. 5 years	500 hrs. 5 years

Everybody Counts: A Report to the Nation on the Future of Mathematics Education and *Project 2061: Science for All Americans*, clearly details the value of the integration of science, technology, and mathematics:

> There are certain thinking skills associated with science, mathematics, and technology that young people need to develop during the school years. These are mostly, but not exclusively, mathematics and logical skills that are essential tools for both formal and informal learning and for a lifetime of participation in society as a whole. (AAAS, 1989, p. 133)

From middle school to the university level, the data indicate a loss of interest in science and mathematics. According to the National Research Council (NRC), approximately one-half of the students leave the mathematics pipeline each year. The National Science Foundation indicates that out of the 4 million high school sophomores in 1977 only 750,000 indicated an interest in natural sciences or engineering. That same pipeline will lead to less than 10,000 Ph.D.s in 1992. NSF predicts a shortage of over 450,000 B.S. degrees in natural sciences and engineering in the year 2,000 (NSB, 1987). About 7 out of 1,000 U.S. students receive an engineering degree, while in Japan, the figure is 40 out of 1,000.

Technology education can help students learn the "doing part" of engineering and natural sciences. It is necessary for instruction to include relevant "real world" problems that cause students to practice and extend their mathematics and science skills. This approach will address the assertion by the National Council of Teachers of Mathematics (NCTM) that knowledge should emerge from experience with real life problems (NCTM, 1989). To help accomplish these objectives, *technology education has the opportunity and obligation to integrate science and mathematics into technology activities*.

Vocational Education Responds

National vocational consortium projects such as *Principles of Technology, Applied Mathematics,* and *Applied Biology/Chemistry* not only discuss the need for such integration but demonstrate ways in which the integration can take place. Similarly, the Carl D. Perkins Vocational and Applied Technology Education Act of 1990 requires that such academics be integrated into vocational education.

Technology Education

Technology education programs such as the ones in Pittsburg, Kansas and Eagle Crest and Delta, Colorado have effectively demonstrated the value of integrating technology with science and mathematics. Technology education programs have shown that such integration is successful. Yet our profession is slow to change.

Roadblocks

The many national and state reports have documented the need to integrate science, technology, and mathematics. There are model programs and complete curriculum packages available to provide such integration. *Then why doesn't more integration take place?* I believe that several roadblocks occur due to the inability of universities and state departments to support and model such integration.

As an example, most people who have reviewed the Principles of Technology curriculum realize the value that Principles of Technology brings to the student. The student uses mathematics, physics, and technology to better understand society in much the same way that an engineer would use that knowledge. Yet, very few universities will accept Principles of Technology as a science credit toward entrance into the university. This roadblock is communicated to counselors and administrators. Many students fear that the university of their choice might frown upon such "integrated knowledge" and not admit them. Similarly, universities have to deal with a transcript that lists "technology education." In most cases technology education credit does little to excite university admission officers. We, the technology teacher educators, must educate the admission offices on our campuses.

Leading By Example

Universities provide few examples of the integration of science, technology, and mathematics. Most frequently, engineering, science, and mathematics departments are run as theoretical units with little knowledge of "doing." Similarly, many practical arts fields such as industrial technology, technology education, occupational therapy, and vocational education promote the doing with little emphasis on the scientific and mathematical base behind the doing.

College Entrance Exams

College entrance exams also work as roadblocks toward the integration of math, science, and technology. ACT and SAT exams are departmentalized and focus on theoretical knowledge with very little, if any, real world application. Many universities across the country are clamoring for the integration of science, technology, and mathematics, but at the same time there is a reluctance to appreciate the value of high school programs that are already accomplishing such integration through technology education, Principles of Technology, Applied Mathematics, and other integrated programs.

Roadblocks to Technology Teacher Education

As university technology education programs try to keep up with the times, they often face the following realities:

- a decreasing undergraduate student population
- decreasing university budgets
- an older tenured staff that is reluctant to change
- old, large, and outdated equipment that is bolted to the floor with emotional ties
- a federal budget of $62 billion of which two-tenths of one percent support educational research (AERA, 1990, p. 5).

Compounding the above problem is the fact that technology education has not found its home in the K-12 system. As Rustum Roy pointed out in a recent article in this journal, (Roy, 1990):

> In the American public's belief system ‘Science’ is a uniform good. The American credo affirms ‘more scientific research’ is certain to be good for the nation. In economic terms, it fails to distinguish between a ‘consumption’ and an ‘investment good.’ Without any thought or reflection, the U.S. public and its leaders base action on the proposition that the supply of ‘basic science’ is infinite, that science leads to applied science which in turn leads to technology and jobs.

Yet, Roy gives the following as a more accurate description of the science and technology relationship:

> 1. Technology leads to science more often than science leads to technology.
> 2. Technology and science are not in the same hierarchical plane in human learning. Technology integrates science's results with half a dozen other inputs to reach a goal.
> 3. Teaching technology and about technology is important for all citizens, while science is an equally important addition for a small (10-15%) subset. (Roy, 1990, p. 11)

Solutions for Our Profession

Professors in the field of technology education must stand up for the value of the content. The integration of science, technology, and mathematics will require that technology teacher educators work hand-in-hand with the other academic areas. In fact, many times the technology teacher will need to lead the other academic areas to rational decisions.

For example, at Colorado State University we are fortunate that our Admissions Office recognizes the value of Principles of Technology and accepts Principles of Technology as a science course for entrance into the University. Colorado State accomplished this by assembling the faculty from the College of Engineering and the Department of Physics and demonstrating to the faculty the value of the Principles of Technology curriculum. The department chair for Physics and the associate dean for the College of Engineering then wrote a letter to Admissions supporting Principles of Technology as one way of obtaining scientific knowledge.

Financial Support

Over the past year, the National Science Foundation and the U.S. Department of Education have supported a wide variety of initiatives that encourage and require the integration of science, technology, and mathematics. Leadership from our national organization has helped establish the Technology Education Demonstration Program. Even with the political pressure to balance the budget, there will be increased support for innovative programs that demonstrate to the country how to produce a person who can understand and use the technological tools of our time. Teacher education institutions that are successful at acquiring federal and state funds will find it easier to overcome the roadblocks that face technology education.

Carl D. Perkins Vocational and Applied Technology Education Act of 1990

For most states it is clear that the single largest impact on technology education will come in the form of the authorization of the Carl D. Perkins Vocational and Applied Technology Education Act of 1990. The new act emphasizes the importance of technology education and the integration of academics into occupational education. We must work together to meet the needs of all youth and give them the education they deserve.

The Accreditation Opportunity

Recently, our national organization (ITEA), through the Council for Technology Teacher Education (CTTE), established specific criteria which are used when the National Council for Accreditation of Teacher Education (NCATE) evaluates teacher education programs. The new NCATE guidelines clearly emphasize the importance of the integration of science, technology, and mathematics. This peer pressure forces technology teacher education institutions to evaluate how they can better integrate science and mathematics into their technology programs. In addition, the NCATE review causes universities to assemble documentation that may be used to assist in acquiring additional funds and provide support for change.

Summary

Although there are many obstacles to the integration of science, technology, and mathematics, there has never been a more exciting time for our profession to embrace such integration. Nearly every national and state report on education highlights the importance of that integration. This emphasis on education is causing an increase in federal and state funds for technology education and its academic counterparts. We have the challenge to follow the CTTE's NCATE guidelines and embrace change and, most importantly, to provide the leadership for the integration of science, technology, and mathematics.

Myth or dream? The integration of science, technology, and mathematics will become reality if we, the technology teacher educators, respond to federal and state requests for proposals, seek the support of science and mathematics educators on our campuses, and focus on the needs of the middle school, high school, and university students. We must be leaders in ensuring that students of all ages, gender, and ethnic backgrounds can participate in society as "doers and thinkers." Technology education provides a hands-on, minds-on approach to science and mathematics. The words of Calvin Woodward, from more than a century ago, are relevant today:

> Hail to the skillful cunning hand!
> Hail to the cultured mind!
> Contending for the world's command,
> Here let them be combined. (Barlow, 1967, p. 36)

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Miscellany

Scope of the JTE

The *Journal of Technology Education* provides a forum for scholarly discussion on topics relating to technology education. Manuscripts should focus on technology education philosophy, theory, or practice. In addition, the *Journal* publishes book reviews, editorials, guest articles, comprehensive literature reviews, and reactions to previously published articles.

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2. All manuscripts must be double-spaced and must adhere strictly to the guidelines published in *Publication Guidelines of the American Psychological Association* (3rd Edition).

3. Manuscripts that are accepted for publication must be resubmitted (following any necessary revisions) both in hard copy and on a 3 1/2" or 5 1/4" floppy disk (either MS-DOS or Macintosh format). Moreover, the disk version must be in both the native word processor format (such as WordPerfect or MS Word) and in ASCII format.

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5. Tables should be used only when data cannot be incorporated into the body of the text.

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