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From the Editor

Will the idea of integrating technology education with other disciplines outlive the Clinton administration? I think it depends on whether you see the glass half empty or half full.

On days when I see it half full, I think of interdisciplinary collaborations among technology, science, math, and other teachers as the stuff of the future. More than any other trend or movement in our field, interdisciplinary collaboration represents an opportunity for the "general education" status we've lusted for throughout this century. We know in our hearts that all children benefit from a better understanding about the technological world in which we live. Technology education is not just good for a few, it is essential for all. But collaboration between technology education and other disciplines in the schools takes it a leap beyond that. It demonstrates the interconnectedness of technology with nearly all aspects of our lives.

Certainly the time is right for technology teachers to "come out of the basement" (where the industrial arts shops of yesteryear were invariably sequestered) and talk to our colleagues about mutually beneficial collaboration. The science and math education establishments are making loud noises about the sort of "hands-on" activities we've taken very much for granted for the past century.

The NCTM (National Council of Teachers of Mathematics, 1989, p. 66) Standards suggest: "Problem situations that establish the need for new ideas and motivate students should serve as the context for mathematics in grades 5-8." Similarly, AAAS (American Association for the Advancement of Science, 1989) recommends: "Science education should utilize a coherent, integrated approach that breaks down rigid disciplinary boundaries and emphasizes connections among science, mathematics, and technology."

Recognizing the need is one thing — making it happen, of course, is altogether another problem. But there are significant efforts now underway. All over the country, interdisciplinary projects involving technology education, science, math, and to a lesser extent language arts and social science are being funded. The National Science Foundation is leading the way. Thus far, NSF has funded "State Systemic Initiative" projects in 20 states (and counting) at $10 million each to develop new approaches to science education. The language behind this initiative includes references to the integration of science, math and technology.

NSF has also funded a number of projects in technology education that are working to integrate the three disciplines. *Phys-Ma-Tech* brought high school physics, math, and technology teachers together to develop curriculum materials. The *Technology/Science/Math Integration Project* is working on integrated middle school activities. *Project UpDate* is developing, collecting and distributing activities that integrate technology, science, and math. And the *Integrating Math, Science and Technology Project* is developing an integrated seventh grade curriculum.

The Technology Education Demonstration projects, funded by the Department of Education (1990), also focused on the integration of these three disciplines. And many state departments of education are funding similar projects that are beginning to result in curriculum materials and changing attitudes about how this content should be delivered.

If it were up to the technology education community alone to bring about widespread collaboration with other disciplines, I would see the glass as half empty. But the education reports of the 1980s have spawned a lot of interesting development in the 1990s. And not just from technology education, but from the other disciplines as well. So widespread integration of technology education with other subjects, particularly science and math, might just happen. Certainly, the opportunity is there. If we miss it, we may not get a second shot.

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Guest Article

Technological Literacy Reconsidered

Walter B. Waetjen

In recent years, the term *literacy* has led a life of its own, particularly as it has become linked with certain programs and catchy slogans. There has been no dearth of attempts to promulgate literacy of all kinds — cultural literacy, adult literacy (read that as *ill*iteracy), computer literacy, geographic literacy, ecological literacy, critical literacy, visual literacy (the study of film), scientific literacy and, yes, technological literacy. Those are all honest intentions to have people become more conversant with the wealth of information about the world and the way in which people should function in it. The difficulty with some of them is that the term is used as if the user knew what it meant. *Saying* a term and *knowing* it are entirely different kinds of human behaviors. To be more pointed, because one uses the term technological literacy does not, in any way, carry with it an understanding of the meaning of technological literacy. Is there any danger in using terms unknowingly and indiscriminately? "Unless we are emphatic in what we advocate... we will have another round of failure.", says Hawkins (1990, p. 1) in discussing the roots of literacy.

Much as we may want to deny it, people can, and do, live without the faintest notion of the nature of technology. They may use technology and its products; but, by no stretch of the imagination could they be described as knowledgeable consumers of technology. Perhaps we need to start over and quiz ourselves as to what a literate person is, forgetting, for the moment, modifiers such as cultural, geographic or technological.

Many attempts to develop literacy carry with them the connotation that literacy, in general, is going to hell in a hand basket. That is not true. For the last century and a half, literacy has been increasing in the United States. In 1850, only one in ten persons could read and write. Now we think it is a tragedy if everyone can't read and write. Statistics prepared by the U.S. government indicate that the literacy rate in the U.S. is in the high ninety percentage range. We know that it is not the case, for many students leaving high school cannot read or write. The difficulty lies partially in definitions. From a governmental point of view, anyone who has completed fifth grade is literate.

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Any educator knows that is a faulty definition. The governmental definition of literacy may serve political purposes, but from a functional point of view it is useless.

Stripping away the verbiage, literacy is the ability to encode and decode a message. If one encodes and decodes very well, he is well-educated at most, or at the least, he can read and write very well. In other words, there is a minimum level of attainment if one is to be literate, but at the same time, there is a range of literacy. The same conditions must apply to technological literacy. That is, technological literacy requires the ability of an individual to code and encode technological messages.

Encoding and decoding means what? The answer is easy in regard to language. It means being able to understand and use words and their meanings. However, let us be certain to make the distinction between orality (speaking a language) and literacy (being able to read and write the language as well as speak it). It's equally easy to define a person who is *numerate*, for that person can code and encode in numbers and form. In discussing literacy, Csikszentmihalyi (1990, p. 119) provokes thought about what technological literacy might be when he says, “Literacy presupposes the existence of a shared symbol system that mediates information between the individual's mind and external events.” What is the symbol system, if any, that characterizes technology and describes its essence? But first, for purposes of clarification, let's examine what is meant by the words “shared” and “symbol.”

Symbols and Literacy

A symbol is any entity that refers to any other entity that may or may not be present. Those entities may be material or abstract and include such things as words, numbers, pictures, diagrams, maps, and almost anything so long as it is interpreted and used as representing some kind of information. Symbols are to be found alone or arranged in a system.

> Symbols can function alone as meaningful entities; but very commonly, they enter as components or elements in a more highly elaborated system. Thus, words figure in spoken or written language; numbers and other abstract symbols in mathematical languages; gestures and other movement patterns within dance systems; and the like. And a considerable range of meanings can be effectively conveyed when entire symbol systems are used; mastering the deployment and the interpretation (the ‘reading’ and the ‘writing’) of such symbol systems constitute a major task for every growing child. (Gardner, 1983, p. 303)

A shared symbol system is simply one that has common meanings and communicates much the same information to a group of people. The group may be large or small, but the symbols have similar information value. Both symbols and symbol systems attain their greatest value in terms of their symbolic products such as: poetry, stage plays, stories, rituals of all kinds, and problem solutions. Could we add the products of technology or the processes of technology to the list? Is there a limit to the number of symbol systems, or can any symbols be arranged into a system? Those questions are key in trying to understand technological literacy.

Does technology have a shared symbol system? The question is rhetorical, leading only to speculation rather than definitive answers. Some would argue that problem-solving, so central to technology, represents a shared symbol system. Then, there are others who might claim that the "technological method" (Savage and Sterry, 1990) is the system of symbols indigenous to technology. Still others imply that the shared symbol system of technology is either a quality of consciousness, a mastery of tools, or both. The fact of the matter is that we have no clear identification of the shared symbol system that may be unique to technology and that, therefore, confuses the matter of achievement of technological literacy. The result is that there is a welter of positions regarding technological literacy.

Literature on Technological Literacy

Many people have written on the subject of technological literacy, all of whom are to be commended for their efforts to describe the complexities of the individual who is literate in technology. Hayden (1989), after a literature review, takes the position that technological literacy is having knowledge and abilities to select and apply appropriate technologies in a given context. While not revealing the source of his thoughts, Steffens (1986, p. 117-118) claims that technological literacy involves knowledge and comprehension of technology and its uses; skills, including tool skills as well as evaluation skills; and, attitudes about new technologies and their application. This insight is similar to that of Owen and Heywood (1986) who say there are three components to technological literacy: the technology of making things; the technology of organization; and, the technology of using information. Applying a Delphi technique to opinions expressed by experts, Croft (1991) evolved a panel of characteristics of a technologically literate student. Those are: abilities to make decisions about technology; possession of basic literacy skills required to solve technology problems; ability to make wise decisions about uses of technology; ability to apply knowledge, tools and skills for the benefit of society; and, ability to describe the basic technology systems of society. Johnson (1989) conceives of technological literacy to be subsumed under scientific literacy with the former type of person having an understanding of the generation of new technology, its control and its uses. The 1991 Yearbook of the Council on Technology Teacher Education is devoted entirely to the subject of technological literacy. This volume examines technological literacy from a variety of angles: its need, as a goal, as a concept, as a program, societal factors influencing it, and in terms of curriculum organization. In this volume Todd (1991, p. 10) says, "Technological literacy is a term of little meaning and many meanings." Later in the same text (p. 11) he makes the statement, "Currently we are unsure whether we are using technological literacy to represent a slogan, a concept, a goal, or a program." The observation has merit.

The literature on technological literacy (going far beyond the sources quoted above) seems to place emphasis on conceptual material, e.g., understandings, knowledge, decision making, etc., and much less emphasis on tool skills, shaping materials, and modeling. This observation, if valid, makes one wonder how so little in the way of praxis could possibly describe a technologically literate person when the *raison d'etre* of technology education is the use of tools, machines and materials. A second inference to be drawn from the literature is the absence of recognition that until technology education has defined its intellectual domain, it is fruitless to try to describe a technologically literate person. The exception to this observation is the opinion expressed by Lewis and Gagel (1992, p. 136) who say, "...to further the goal of technological literacy, schools would seem to have two clear responsibilities; first, to articulate the disciplinary structure of technology and, second, to provide for its authentic expression in the curriculum." The remark is squarely on target and deserves further comment.

Intellectual Domain and Technological Literacy

When one thinks carefully about technological literacy, it is easy to recognize it as an outcome measure. That is, it comes as a result of what is in the curriculum and methods used by the teacher to impart the curriculum. But from whence comes the curriculum? From individual teacher whimsy? From the opinions of an "expert"? The proper answer is that "...the inherent structure of any discipline is the only proper source of learning content; ..." (Inlow, p. 15, emphasis added). Does technology education have a structured body of knowledge, of organizing concepts, of underlying ideas and fundamental principles that define it as an academic discipline? It does not. And because it doesn't, it follows that there is no valid way of determining curriculum content. "If that be true, how can we even hope that technological literacy will be achieved by students if technology education has no structured domain of knowledge. They could not." (Waetjen, p. 8)

As a profession, technology education has been preoccupied with the concept of technological literacy — or so it seems, judging by the wealth of literature of the subject. If that same amount of thought and energy had been directed to defining technology education as an academic discipline, it would be far better off as a profession. It is interesting to speculate whether technology education would have higher prestige if that had happened; or, if fewer technology education programs would have been eliminated.

The precursor to the pursuit of the holy grail of technological literacy is for technology education to take concrete steps to establish itself as an academic discipline. It will take more than strong statements or hastily conceived position papers. Those would serve only to make technology education "an enterprise of methodical guessing", to use Bertrand Russell's words. To become an academic discipline, technology education must specify four things. First, it will have to identify an intellectual domain consisting of a body of credible organized knowledge that is unique, is related to man's concerns in living, and is an array of ideas related in sequential fashion. Second, an academic discipline has a history of the organizing concepts that constitute its domain. Third, there must be a clear delineation of the modes of inquiry by which the discipline validates itself, creates new knowledge, and advances as a discipline. Finally, an academic discipline must be instructive; curriculum content must derive from its intellectual domain. (For a fuller discussion of these four elements, see Waetjen, 1992). Had technology education directed its efforts to the above four elements, it would be on far firmer intellectual ground in its debates and writings on technological literacy. It is not possible to define technological literacy, or measure it, in the absence of an agreed upon intellectual domain for technology education.

End Notes

No matter how the intellectual domain of technology and its resulting curriculum are ultimately defined, there will then be a logical basis for determining the nature of technological literacy. To speculate on the nature of the first two of those three considerations is entirely outside the scope of this discourse. Yet, they will be the genesis of the third consideration — technological literacy. Because of that line of conceptual evolution, we must wait to crystallize the full meaning of technological literacy; but, there are some things that can be said about it now, simply because it is an outcome phenomenon, a human learning.

If technological literacy is based on a symbol system of some sort (and it probably is) then, like the learning of all other symbol systems, there will be developmental variations in its achievement. A student at age ten may be technologically literate, but at age fifteen may not be. Obviously, there are implications regarding teachers' expectations in this connection and so are there implications for those who write about technological literacy and those who seek to measure it. Technological literacy is not an all-or-none learning and should not be described in those terms.

When the profession gets around to defining technological literacy according to the process described above, care will have to be taken to define it at *minimum* for any given developmental stage. The literature too often implies grandiose or maximal levels of achievement of literacy in technology. Caution is predicated by the fact that a given student, for example, may be highly literate when it comes to electronics and considerably less literate about systems of manufacture. That unevenness may be due to variations in teaching, to curriculum content, to student interests, or to a host of other reasons. Whatever the case, the unevenness is not to be decried, for it is an indication of individual human development.

In a world replete with those who swear at or swear by technology, those in the profession must use the term technological literacy with caution. It surely cannot be a neutrally intended term since it is related to educational endeavors and all such endeavors are laden with purpose or value, whether we like it or not, and whether we intend it or not. How can we possibly convince parents, *et al*, that technology education is to be included in the curriculum, and young people are to become technologically literate, if we don't have clearly in mind the intellectual domain of technology education, or the purposes served by a person becoming technologically literate?

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Articles

The Development of Problem Solving Capabilities in Pre-service Technology Teacher Education

Richard A. Boser

Enhancing the problem solving capabilities of students and employees has become a national educational issue. The Commission on Pre-College Education in Mathematics, Science and Technology (1983) declared that “problem-solving skills, and scientific and technological literacy — [are] the thinking tools that allow us to understand the technological world around us” (p. v). More recent reports that have focused on entry-level workplace skills by Carnevale, Gainer, and Meltzer (1990) and United States Department of Labor (1991) [SCANS Report] also underscore the importance of developing students' problem solving abilities. As a result of this decade of emphasis on problem solving, efforts to enhance the capabilities of students to solve problems have reached most disciplines and most educational levels (Birch, 1986; Bransford, Goin, Hasselbring, Kinzer, Sherwood, & Williams, 1986; Kulm, 1990; Lombard, Konicek, & Schultz, 1985; Thomas & Englund, 1990).

In technology education, teaching through problem solving methodology has become a central focus of instructional activity (Waetjen, 1989). It follows, therefore, that teachers need to be adept at using problem solving strategies in their classrooms and laboratories. Several recent studies highlight this need. Barnes (1987) concluded that problem solving should be a key descriptor for defining technology and a curricular organizer for the study of technology. Householder and Boser (1991) reported that an emphasis on problem solving instructional strategies was a key ingredient in assessing the effective implementation of pre-service technology teacher education programs. In addition, research by Horath (1990) and by Householder and Boser pointed to the need for graduates of technology teacher education programs to use problem solving strategies in their classrooms and laboratories and to teach problem solving skills. In spite of the need to implement effective problem solving instruction

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in pre-service technology teacher education, there is no generally accepted framework to guide curriculum development or assessment procedures.

Background Ideas

One difficulty in investigating problem solving behavior is the many usages of the phrase “problem solving”. McCormick (1990) noted that, depending on the context, “problem solving” may mean: (a) a teaching method that encourages active learning, (b) a generic ability to deal with problem situations, (c) a method used in such subjects as mathematics or science, or (d) an empirical investigation. Additionally, Gagne (1985) used the term problem solving to describe a higher-order intellectual ability and a way of learning.

All of these usages have implications within technology teacher education. Problem solving is clearly seen as a teaching method with links back to experiential learning. Problem solving may also be viewed as a way of learning that generates new insights and useful thinking processes for the learner (Gagne, 1985). Further, the scientific method of hypothesis generating and testing is certainly at the heart of technological problem solving. In this study, because of the implications for teacher education, “problem solving” was limited to two usages. First, “technological problem solving” refers to the systematic way of investigating a situation and implementing solutions. Second, the “problem solving approach” is used to describe a teaching method that encourages the development of new insights and useful thinking processes through active investigative learning.

Technological Problem Solving

Technological problem solving processes have been greatly influenced by the work of Dewey and Polya (Savage and Sterry, 1991). Dewey (1910) described a five step iterative process of problem solving that comprised: (a) felt difficulty, (b) clarification of the problem, (c) identification of possible solutions, (d) testing the suggested solutions, and (e) verification of the results. Polya (1957) proposed a heuristic process for solving problems in mathematics that provided a mental guideline for action. The steps in Polya's heuristic included: (a) understanding the problem, (b) devising a plan, (c) carrying out the plan, and (d) looking back — checking the results and evaluating the solution.

Two additional influences on technological problem solving have been the scientific method and the idea of creative problem solving. de Bono (1990) postulated that the concept of the “hypothesis”, which formally sanctions creativity and imagination, has been “the” idea that has powered rapid scientific and technological change. Wallas (1926) described the creative problem solving process as involving four phases: (a) preparation, (b) incubation, (c) illumination, and (d) verification. More recently, Devore, Horton, and Lawson (1989) built upon the work of Wallas and added two additional phases: motivation and manipulation.

These approaches have formed the basis for many models of problem solving that have been applied in technology education. Some of these models retain the simple linear approach, such as the IDEAL model of Bransford and Stein (1984), while others, such as Barnes, Wiatt, and Bowen (1990) and Hutchinson (1987), have proposed more complex circular or spiral models with evaluation components built into each phase.

Problem Solving as an Instructional Approach

The problem solving approach immerses students in active, investigative learning (Sellwood, 1989). Through participation in a series of practical problem solving activities that may involve designing, modeling, and testing of technological solutions it is assumed that the learner will acquire both technical knowledge and higher-order cognitive skills. Gagne (1985) stressed the importance of experiential learning and noted that abstract concepts must be built upon concrete situations in order to “operationalize” (p. 103) declarative knowledge. Andre (1986) emphasized that the importance of problem solving methods lies in the degree of information processing required of the learner. In identifying problems, searching for solutions, and presenting results, the learner has multiple opportunities to encode and accommodate new knowledge.

Preparation to Teach Problem Solving

No research was found that related training in problem solving methods to pre-service technology teacher education. However, Diaber (1988) noted many common instructional elements among “investigative delivery systems” (p. 166) such as problem solving, inquiry teaching, discovery learning, and critical thinking. Given the commonalities, research in these related areas may provide useful insights to teacher educators.

A meta-analysis of inquiry teaching studies in science education by Sweitzer and Anderson (1983) reported that effective teacher preparation procedures included: (a) systematic observation of inquiry practices; (b) microteaching; and (c) feedback, in which supervisory conferences were combined with videotaped observations. More recently, Hutchinson (1989) found that pre-service teachers who participated in an inquiry-oriented seminar assumed more active teaching and learning roles than those teachers who participated in a traditional seminar setting. Fernandes (1988), who compared the effects of explicit and implicit teaching of a Polya's (1957) heuristic model of mathematical problem-solving, reported that both approaches significantly enhanced the problem solving performance of pre-service teachers. However, only explicit instruction resulted in the conscious use of the heuristic. Fernandes concluded that in order to teach problem solving teachers must be competent problem solvers who are aware of the methods and processes that they employ.

These studies support the idea that changes in ways of preparing teachers will result in changes in classroom performance. Moreover, as Wright (1990) stated, being a competent technological problem solver is, by itself, insufficient preparation to teach problem solving skills. Pedagogical skills and practices that foster students' problem solving abilities must be taught to prospective teachers.

Purpose of the Study

Although a host of implications for instruction have been offered from the research on problem solving in various domains, relatively few studies have addressed the need to prepare teachers to teach higher-order thinking skills such as problem solving. Little is known about the experiences in which pre-service technology education teachers should participate in order to acquire the skills needed to be competent technological problem solvers and to use problem solving effectively as an instructional methodology in the secondary school classroom or laboratory. The purpose of this study was to develop a validated inventory of instructional procedures, techniques, and assessment methods that may be used by the profession as a framework for curriculum development and for the assessment of program effectiveness in the development of problem solving capabilities in pre-service technology teacher education programs.

Research Questions

Two sets of instructional practices were investigated: (a) procedures recommended to acquire the skills needed to be competent technological problem solvers, and (b) procedures that facilitate the use of problem solving teaching methods in the secondary school classroom or laboratory. Each of the two sets of instructional practices was organized into three parts: (a) procedures recommended to develop the problem solving capabilities, (b) instructional techniques for putting the procedures in place, and (c) methods for assessment of program effectiveness in delivering the procedures. Specifically, the following research questions were used to guide the study:

1. Are leading practitioners and advocates of problem solving instruction within the field of technology education in agreement with leading educators and psychologists who are not in the field of technology education as to which procedures are effective in the development of problem solving capabilities?
2. What procedures are recommended to develop the technological problem solving capabilities of prospective teachers during pre-service technology teacher education programs?
3. What instructional techniques are appropriate for the delivery of the procedures recommended to develop the technological problem solving capabilities of prospective teachers?
4. How may the effectiveness of the procedures recommended to develop the technological problem solving capabilities of prospective teachers be assessed?
5. What procedures should be included in pre-service technology teacher education programs to assist teachers in using a problem solving methodology?

6. What instructional techniques provide an effective means for delivering the procedures designed to assist teachers in using a problem solving methodology?
7. How may the effectiveness of the procedures recommended to assist prospective teachers in using a problem solving methodology be assessed in pre-service technology teacher education programs?

Procedures

Perceptions of effective instruction were solicited from two selected panels of experts in problem solving. One panel was comprised of technology teacher educators (TECH) who were identified as leading practitioners or advocates of problem solving instruction (n = 10). These panel members were identified from the a group of 22 leading technology teacher educators who previously served as Delphi panelists in the study by Householder and Boser (1991). The selection of TECH panelists was based upon their interest in problem solving as evidenced by (a) recent research, writing, and presentations on problem solving instruction, and (b) rating of the importance of problem solving items in response to a questionnaire conducted by Householder and Boser. The second panel included leading educators and psychologists (EXT) who have published in the area of problem solving and who were not in the field of technology education (n = 9).

There were two reasons for using two panels. First, expertise from outside technology teacher education may broaden the pool of instructional procedures recommended to the profession through this research. Barnes (1987), who indicated the need to broaden the curricular organizers of technology education, consulted practitioners in several professions outside of technology education. Second, utilizing two panels provided data for comparing the perceptions of the experts within technology education with the recommendations of experts external to the field.

Potential panel members were contacted by telephone to seek their participation in the study and to establish a convenient time to conduct the telephone interview. Depending on the amount of lead time prior to the scheduled interview, a letter confirming the scheduled interview time was either mailed or faxed to the panelist. Enclosed with the confirmation letter was a copy of the telephone interview schedule, a brief orientation to the study, and a listing of pertinent definitions. The interview times ranged from 10 minutes when the respondent had completed the survey in advance of the conversation, to 45 minutes when the items were reviewed and recorded during the discussion.

In semi-structured telephone interviews, panelists were asked to rate the relevance of an inventory of procedures (70 items) synthesized from the literature, to comment on those procedures, and to suggest additional procedures that they considered essential in the development of problem solving capabilities. A 10-point scale was used by panelists to rate the procedures with a rating of 10 indicating that the procedure was absolutely essential. A rating of one implied that the recommendation was not relevant. The 10-point scale was assumed to have yielded interval data (Nunnally, 1978). This scale was selected because of the potential for increased reliability in comparison to scales with fewer intervals (Nunnally, 1978), and also because of its conversational appeal in an interview setting. That is, it is quite common for individuals to be asked to rate objects, ideas, or perceptions on a scale of 1 to 10.

The telephone interview schedule was pilot tested with subjects not included in the research sample. The individuals who comprised the sample for the pilot test were teacher educators who had recently completed doctoral research or who had a record of publication in the area of problem solving instruction.

Descriptive statistics calculated for each of the 70 items included the combined mean score and standard deviation, the mean score and standard deviation by panel, the frequency of rating scores, and measures of kurtosis and skewness. Both the t-test procedure and Wilcoxon's Rank-Sum Test were used to test for significant differences in the responses between the two panels.

Results and Discussion

Of the 70 items rated by panelists, only the instructional methods of “Computer Assisted Instruction” and “Lecture” received mean rating scores of less than 6 on the 10-point scale. Even these instructional techniques were the subject of mitigating comments from panelists as to their appropriate contexts in teaching problem solving. As a group, therefore, the procedures synthesized from the literature have a high degree of relevance for the preparation of preservice technology education teachers.

Agreement Between Panels

Analysis of the results with both parametric and nonparametric statistical procedures indicated that there was no significant difference in the mean rating scores assigned to the items by the two panels. The overall mean rating score of the 70 items by the TECH panel was 8.07 on the 10-point scale. The mean rating score of the EXT panel was 7.76. The SD for both panels was 1.13. As a result of these findings, the combined mean scores of both panels (n = 19) were used to rank the inventory items.

Developing Technological Problem Solving Capabilities

Recommended procedures. All 19 items in this section received a mean rating greater than 6 on the 10-point scale. Four procedures that emphasized practice in applying problem solving strategies in realistic contexts and feedback on the use of those strategies received mean ratings of nine or greater. Other highly-rated items recommended that prospective teachers have the opportunity to observe the regular modeling of problem solving behavior and the cognitive modeling of thinking processes involved in solving problems. The panelists' responses are reported in Table 1.

Table 1

Instructional Procedures Recommended to Develop Technological Problem Solving Capabilities

Mean	SD	Recommended Procedure
9.42	0.69	Problem solving strategies are practiced in meaningful contexts
9.32	0.88	Feedback is provided on the use of problem solving strategies
9.24	1.15	Discussion questions emphasize "why and how"
9.05	0.91	Concepts and principles are connected to real world application
9.00	1.66	Problem solving behavior is regularly modeled
8.89	1.07	Alternative problem solutions are explored

Table 1 (cont.)

8.83	1.04	Realistic problem situations span the range of technological activities
8.63	1.26	Systematic verification processes are used to check results
8.63	1.50	Small group problem solving procedures are analyzed through inter-group discussion
8.42	1.57	Feedback helps teachers interpret their experiences
8.05	1.71	Problem solving thinking processes are regularly modeled through such practices as “talk aloud” methods and self-monitoring questions
8.00	1.83	Learning activities are linked to broad problem situations
8.00	1.87	Techniques and processes central to technological activities are emphasized through extended practice
7.89	2.66	General problem solving strategies (heuristics) are specifically taught
7.79	1.75	Sources of incorrect procedures are confronted
6.83	2.52	Worked-out examples are provided when appropriate
6.79	1.99	Concepts developed through problem solving activities are confirmed in discussion with more experienced persons
6.32	2.31	Prompts, such as checklists, are readily available to guide problem solving performance
6.05	3.13	Initial learning of strategies focuses on the skill rather than content

Teaching methods. Whereas there was considerable agreement between the panelists as to which procedures promote the development of problem solving abilities, no corresponding consensus developed on which instructional techniques might be used to facilitate those procedures. With the exception of small group problem solving experience, panelists' ratings of the techniques appeared to reflect familiarity with the practices. Members of the TECH panel tended to rate most highly those procedures practiced within the field, such as design-based problem solving, R & D experiences, and innovation activities. EXT panelists considered techniques such as simulation and case study, which are perhaps more widely used in content areas outside of technology education, as appropriate delivery vehicles for the recommended problem solving procedures.

Comments by several panelists emphasized the need to use a variety of instructional techniques. One panel member commented that all of the instructional techniques could be highly relevant in the proper context. Moreover, as a panelist suggested, practice in applying problem solving skills in a variety of instructional settings may facilitate transfer of those skills to novel situations. Variety itself may have implications for the types of activities graduate technology education teachers chose to implement in their classrooms. Panelists ratings of the items in this section are reported in Table 2.

Table 2
Instructional Techniques That Facilitate the Use of the Procedures Recommended to Develop Technological Problem Solving Capabilities

Mean	SD	Recommended Procedure
9.29	1.10	Small group problem solving experience
8.61	1.42	Individual problem solving experiences
8.50	1.29	Simulation
8.44	1.92	Design-based problem solving
8.19	1.97	Cooperative learning
7.94	2.94	Research and development experience
7.89	2.35	Innovation activity
7.89	2.39	Invention activity
7.41	2.06	Community-based problem solving
7.25	2.29	Enterprise (class models a corporation)
6.71	2.73	Case study
6.53	2.39	Self-instruction through manuals etc.
6.50	2.17	Demonstration
6.44	2.30	Peer teaching
5.50	2.09	Computer assisted instruction (CAI)

Assessment of program effectiveness. Of the eight assessment methods rated by the panelists, only “outcomes from group problem solving activities” had a standard deviation (SD) of < 1.00. For all the other items the SD was > 2.00. Although as a group the items are highly rated, the relatively large SD for these assessment methods suggested that there is little agreement among panelists as to the perceived relevance of these methods. Panelists' ratings of these items is presented in Table 3.

The comments on the items run somewhat contrary to the item ratings. Panelists expressed reservations about all but the three most highly ranked items. Several panelists were concerned about the “school smarts” of students. One panel member commented that structured interviews might not be a viable way to get at program effectiveness because “students know which answers are valued by the teacher.” Panelists rankings and comments indicated a need for specific observable measures from which to assess the effectiveness of problem solving capabilities.

Table 3
Methods for the Assessment of Program Effectiveness in Delivering the Procedures Recommended to Develop Technological Problem Solving Capabilities

Mean	SD	Recommended Assessment Method
8.83	0.78	Outcomes from group problem solving activities
8.39	2.23	Performance samples of a specific problem solving phase
8.11	2.35	Examples of problem solving by the teacher
7.94	2.38	Written or verbal rationales for decisions
7.37	2.26	Structured interviews
7.00	2.27	Holistic scoring (points awarded for each stage of the problem solving process)
6.95	2.06	Informal questioning during instructional activities
6.47	2.30	Teacher self-inventories of their problem solving abilities

Training Teachers to Use Problem Solving Teaching Methods

Procedures that promote the use of problem solving teaching methods. Ten of the 11 items in this section had a mean rating > 7.89. The limited range of the mean scores and the high mean ratings of the items indicate that the procedures have a high degree of relevance in assisting pre-service technology education teachers in using a problem solving teaching methods. Visual categorization of the procedures suggests that the principal instructional component in promoting the use of the problem solving approach are: (a) practice with multiple forms of feedback, (b) opportunities to regularly observe the modeling of problem solving instruction and the associated cognitive processes, and (c) reflection upon the application of problem solving instruction in the classroom. The tabulated results of the items in this category are presented in Table 4.

Panelists provided extensive comments on the items in this section and typically elaborated upon an item or sought to combine ideas. For example, one panelist highlighted the importance of mediated observation

Table 4
Instructional Procedures Recommended to Promote the Use of Problem Solving Teaching Methods

Mean	SD	Recommended Procedure
9.00	1.00	Problem solving theory is specifically linked to classroom practices of teachers.

9.00	1.32	Teachers receive multiple forms of feedback on their use of the problem solving approach (e.g. instructors, videotapes, and supervisory conferences)
9.00	1.49	Problem solving instructional methods are regularly modeled
8.89	1.10	Teachers evaluate their own problem solving strategies and discuss their application to the teaching of children
8.63	1.64	Thinking processes used to facilitate problem solving instruction are regularly modeled through “talk aloud” strategies and self-monitoring questions
8.53	1.68	Teachers participate in the systematic observation of problem solving practices in the classroom and laboratory
8.42	1.61	Steps that comprise the problem solving approach are clearly defined and practiced in a microteaching environment
8.26	2.05	Coaching in the use of problem solving methods is gradually reduced as teacher competence increases
8.22	1.26	Lesson planning accounts for individual differences in students' problem solving abilities such as the confidence and competence of the problem solvers
7.89	2.13	Pre-service problem solving activities are similar to those that teachers will present to their technology education students
6.78	2.23	Teachers predict and visualize the outcomes of lesson planning

and multiple forms of feedback by stating that, “Any type of feedback can be useful, but it must be articulated feedback with specific suggestions for improvement. Even in looking at a videotape, someone usually has to point out what to watch for.”

Teaching methods. With the exception of lecture and case study, which had mean scores of 5.21 and 6.84 respectively, the mean scores of the other eight instructional techniques fell within a limited range from 7.53 to 9.11 on the 10-point scale. Student teaching was the highest rated technique in this group and the only item with a mean score > 9.00. Panelists' ratings of these items are reported in Table 5.

Comments by panel members suggested that choice of technique is not necessarily as critical as factors related to the implementation of the technique, such as frequency of use or appropriate sequencing during the teacher education program. While student teaching was the most highly ranked technique, several panelists commented that this experience would only be useful if the cooperating teachers were carefully selected.

Table 5
Instructional Techniques for the Implementation of the Instructional Procedures Recommended to Promote the Use of Problem Solving Teaching Methods

Mean	SD	Recommended Procedure
9.11	1.37	Student teaching
8.72	1.41	Induction year
8.50	1.46	Simulation
8.39	1.61	Cooperative learning
8.16	1.46	Micro-teaching
8.00	1.56	Demonstration
7.79	1.58	Peer teaching
7.53	2.11	Discussion
6.84	3.07	Case study
5.21	2.59	Lecture

Assessment of program effectiveness. Although there were only five items in this section, a visual examination of the mean responses indicated two groups of assessment methods. The two most highly rated items, systematic observation of teacher performance during student teaching (9.00) and focused interviews (8.21), emphasized a structured approach to assessment. The remaining items relied on more indirect measures or self-report to assess teachers' use of problem solving teaching methods.

The comments of panelists reflected a general skepticism of any form of assessment based on self-report by the learner. Additionally, comments reinforced the need for assessment methods to be based on observed performance that can be checked against established benchmarks. The tabulated responses to the items in this section are presented in Table 6.

Table 6
Methods for the Assessment of Program Effectiveness in Delivering the Procedures Recommended to Promote the Use of Problem Solving Methodologies

Mean	SD	Recommended Procedure
9.00	1.37	Systematic observation of teacher performance during student teaching
8.21	1.68	Focused interviews
7.00	1.45	Children's performance during teachers' field experience (student teaching)

6.89	2.60	Journal reports from student teaching
6.79	2.37	Informal questioning during instructional activities

Additional Procedures Suggested by Panelists

Panelists suggested 46 additional procedures which they considered essential for the development of the problem solving capabilities. Combining the individual suggestions resulted in a listing of 25 additional items. A pilot test to validate the relevance of these additional procedures was conducted as an adjunct to this study. On a mailed questionnaire, panelists were asked to rate the additional procedures. The questionnaire format and item rating procedures used in the pilot test were identical to those processes used during the initial interviews. Eighteen of the panelists (94.7%) returned rating sheets. Analysis of the data indicated similarities in skewness, mean rating scores, and standard deviations between the additional procedures and the procedures recommended through the review of literature. Therefore, the additional procedures also appear to be relevant to development of problem solving capabilities. However, because of methodological differences only selected items will be discussed.

Technological problem solving. The most highly ranked instructional procedure, 9.11 on the 10-point scale, suggested that “Alternative ways of looking at the problem should be considered in the search for a solution.” Although this item appears to be a step in the technological problem solving process, it is also consistent with the information processing concept of looking for a representation of the problem that makes a solution more likely. The modeling of “looking for alternatives” as technical problems are addressed may be a large step in promoting a problem solving thinking approach.

In the assessment section, if “Instructor models problem solving behavior” had been considered among the initial group of inventory items, it would have been the most highly rated item (mean rating = 8.89). Moreover, this was the only assessment method that did not relate program effectiveness in the delivery of problem solving instruction to some measure of learner outcome. Perhaps evidence of instructor modeling of problem solving behaviors is a powerful indicator of program effectiveness.

Training teachers to use problem solving teaching methods. The instructional procedures and techniques suggested in this section tended to elaborate on the more general items recommended in the initial inventory. Many of the items focused on some aspect of observational activity or field experience. However, the two most highly rated methods for the assessment of program effectiveness are clearly different from the items in the initial inventory. One suggested that, “Teachers analyze videotaped segments of their actual teaching or micro-teaching” (mean rating = 7.94), whereas the second item recommended that, “Teachers analyze situations presented on videotape or videodisc in relation to specific program goals” (mean rating = 7.06). The use of these two methods may offer a controlled way to systematically examine program outcomes.

Summary and Conclusions

The inventory of procedures was highly rated by panelists and the increments between adjacent rankings were too small to establish meaningful cut-off points. Therefore no attempt was made to categorize the items within the sections. Clearly, in the correct context, all of the items may contribute synergically to the development of effective problem solving instruction. Given the small mean differences between adjacent rankings in the inventory, instructors and curriculum designers are advised to consider the procedures within each section as a group, and select procedures based on instructional objectives and situational context. Further, as indicated by panelists comments, factors such as the frequency of use and appropriateness of the procedures or techniques at the learners' current stage of development must obviously be considered.

In general, the ratings and comments by panelists indicated that the development of technological problem solving capabilities was typified by: (a) modeling and practice with feedback in realistic situations, (b) a variety of relevant instructional techniques, and (c) a collection of outcome measures to assess program effectiveness. Additionally, training teachers to use problem solving teaching methods involved: (a) modeling, mediated observation, specific practice with feedback in using problem solving teaching methods, and reflective discussion on the application of these teaching methods; (b) carefully selected field experience sites; and (c) performance based assessment. Specifically, the following conclusions were derived from this study:

1. The inventory of instructional procedures, techniques, and assessment methods compiled and rated through this research provide a relevant framework for the development of the problem solving capabilities in pre-service technology teacher education.
2. Procedures and methods advocated by technology teacher educators were not significantly different from those recommended by the EXT panel of authors and educational psychologists. Therefore, it makes sense to utilize the expertise within the field of technology education when designing instruction intended to facilitate problem solving capabilities.
3. Instructional procedures that characterized the development of technological problem solving capabilities included the: (a) application of problem solving strategies with appropriate feedback in variety of realistic situations, (b) observation of behavioral and cognitive modeling, and (c) development of connections between concepts and applications.
4. Although “small group problem solving” was the most highly ranked instructional technique for the development of technological problem solving capabilities, panelist considered it appropriate and desirable to employ a variety of techniques.
5. Methods for the assessment of program effectiveness in delivering technological problem solving instruction included: (a) outcomes from group

and individual problem solving activities, (b) performance samples, and (c) self-reports.

6. Instructional procedures that promote the use of problem solving teaching methods included: (a) the development of linkages between theory and practice, (b) multiple forms of feedback on practice teaching activities, (c) modeling of appropriate methods, and (d) mediated observation of problem solving instruction and reflective discussion on the application of those teaching methods.
7. Field experience that is conducted in carefully selected sites and that emphasizes problem solving teaching methods was identified as the most effective means of training pre-service teachers to use those teaching methods.
8. Systematic observation of teachers' performance during student teaching was the most highly rated method for the assessment of program effectiveness in promoting the use of problem solving teaching methods.

Implications for Technology Teacher Education

Technology education teachers need to develop technical expertise, problem solving skills, and the ability to foster the problem solving skills of their students. These abilities will not likely occur by chance. The competencies needed to teach problem solving must be taught to prospective teachers. The inventory of procedures validated in this study may form a useful set of recommendations for practice. These recommendations may serve to guide the selection of instructional practices, the development of curriculum, and the assessment of problem solving instruction in pre-service technology teacher education. Based on appropriate sections of the inventory, checklists may be developed to provide a formative assessment of the problem solving teaching methods used by instructors or to guide specific feedback to practice teachers. Research indicates that changes in ways of preparing teachers will result in changes in classroom performance. The challenge to technology teacher educators is to select and implement the most effective teaching procedures.

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Mathematics, Science, and Technology Teachers' Perceptions of Technology Education

Michael K. Daugherty & Robert C. Wicklein

After a decade of accelerated change in the technology education discipline, curriculum and philosophical changes are evident throughout many of the programs in America. Few individuals in the profession are not aware of the new emphasis being placed on presenting mathematics and science concepts in a technological framework. However, there seems to be persistent confusion outside the discipline, particularly in the disciplines of mathematics and science, as to what characteristics exemplify technology education. If technology education is to assume its stated role of providing interdisciplinary settings for the application of mathematics and science concepts, efforts must be made to understand and inform those disciplines with which we choose to associate (e.g., mathematics, science).

In March 1990, President Bush and the nation's 50 Governors established a set of six national education goals for the United States to reach by the year 2000 (Miller, 1990). These national goals addressed perceived major problems in the country's educational systems. One of the six goals called for a concerted effort toward increasing the mathematics and science proficiency of America's student body (Stern, 1991). Barry Stern, Deputy Assistant Secretary of Vocational and Adult Education of the U.S. Department of Education, reported that: “If the United States is to achieve these goals, especially the goal on mathematics and science, technology education is likely to play an important role” (p. 3). Stern continued, “If we are serious about improving mathematics and science achievement, and indeed, the overall educational performance of our students, we must explore different ways of teaching and organizing curricula. Technology education is one of those ways....” (p. 3).

The technology education discipline has undergone revolutionary changes in the past decade (e. g. Snyder and Hales, 1982, Savage and Sterry, 1990). Professionals within the field have called for a discipline more closely aligned with mathematics and science (Maley, 1985, 1989; Welty, 1990; Lauda, 1989). In the Project 2061 Technology Panel Report, F. James Rutherford (1989), Project Director, stated that: “America has no more urgent priority than the

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reform of education in science, mathematics, and technology" (p. vii). Rutherford further implied that the task ahead for the United States is to develop a new system of education that will prepare young people who are literate in science, mathematics, and technology. Rutherford concluded that the sciences and mathematics are important to the understanding of the processes and meaning of technology and their integration with technology education is vital for a technologically literate student. Fagan (1987) suggested that the technology education curriculum should be guided by the technological literacy needs of students instructed in an interdisciplinary setting. The International Technology Education Association (ITEA) strategic plan outlines, as one of the association's major goals, the establishment of technology education as the primary discipline for integrating curriculum towards the advancement of technological literacy (International Technology Education Association, 1990). While many outside of technology education support this notion (Boyer, 1985; Selby, 1988; Roy, 1989), it is apparent that the shift in emphasis within the profession must be matched by emphases from complementing disciplines (Renzelman, 1989).

Recent research indicates that there is considerable confusion in adjoining disciplines as to what characteristics exemplify technology education (Maley, 1989; Wenig, 1989). The past decade has been marked by many changes and reforms in the technology education discipline. However, establishing technology education as a viable school subject within the public schools will be a major challenge facing technology education (Maley, 1989). Wenig (1986) suggested that for the discipline of technology education to survive and thrive, moves must be made to clear up any confusion adjoining disciplines have about technology education and proceed towards a coordinated curriculum of complementary subject matter. While technology education has made considerable strides in curriculum and program development in the past decade, it is not clear whether the impact of this evolution has been felt or understood by the educational decision makers and the members of complementing disciplines. Betts, Yuill, and Bray (1989) point out that: "The problem appears to be that those who make decisions affecting our program do not have a positive image of our program" (p. 27). Stone (1989) emphatically pointed out that: "Unless there can be an awakening of the true role of technology education in the minds of these decision makers, there will not be any shift in the focus of education. Instead there will be new wine in old bottles" (p. 40). Selby (1988) indicated that outmoded ideas and misguided perceptions are the common enemy of all disciplines. Similarly, Dyrenfurth (1987) suggested that while technology education is considered an essential characteristic of quality education, there are often misinterpretations and misrepresentations associated with technology education. Throughout the literature on technology education, misrepresentations and stereo-typical perceptions of technology education can be found. Boyer (1983), in his study of technology in schools, found a disturbing trend of equating technology education with computer literacy programs. Similarly, Stone (1989) found that one serious misconception is the confusing of technology education with educational technology. Technology must make a concerted effort to erase these widely held misconceptions, assuming the task of educating the masses about the role and function technology education plays in the total educational curriculum.

Purpose

The purpose of this research was to determine the perceived characteristics affiliated with the technology education discipline as discerned by technology education professionals and associated secondary education faculty (i.e., mathematics and science teachers). The efforts to integrate technology education into secondary education school curriculum can not be effectively implemented until there is clear understanding of the purpose of technology education by all members of the technology education, mathematics, and science faculties.

Based on the purpose of this study, the following research questions were developed for investigation:

1. What are the characteristics that exemplary technology education classroom teachers identify with technology education?
2. What are the characteristics that associated secondary education faculty (mathematics and science) identify with technology education?
3. Is there a significant difference between the perceptions of the exemplary technology education classroom teachers and the perceptions held by associated secondary education faculty in science and mathematics?

Methodology

The population for this study consisted of two primary groups, (1) Exemplary technology education teachers and (2) Associated secondary education faculty (i.e., mathematics teachers, science teachers). The exemplary teachers of technology education were identified by prior research conducted by Wicklein (1992). Through the use of a mailed questionnaire, Wicklein surveyed representatives from all 50 states, these representatives consisted of 64 university professors and department heads of technology education as well as 50 state supervisors of technology education. The 154 exemplary technology education teachers identified by Wicklein were used to establish the exemplary technology education teacher sample of this research.

The associated secondary education faculty participant sample was drawn from representatives of the disciplines of mathematics and science and were located within the same school as the previously identified exemplary technology education teachers.

Instrumentation

Due to the relatively large size of the population, the instrument chosen for the study was a mailed questionnaire. Fink and Kosecoff (1985) suggest that the mailed questionnaire is the most reliable and valid method of economically obtaining large amounts of information from people. This study utilized a mailed questionnaire developed by the researchers and was based on the content model for the study of technology, *A Conceptual Framework for Technology Education* (Savage & Sterry, 1990).

The objective of the questionnaire was to allow all respondents the opportunity to express their perceptions of the characteristics exemplifying the technology education discipline in the following categories: (1) Methodological characteristics, (2) Curriculum content characteristics, (3) Integration perceptions, and (4) Action plans. The methodology category was utilized to collect data concerning the methodological approaches perceived to characterize the technology education discipline, while the content characteristics category was utilized to identify course content for technology education. The third section of the questionnaire sought to identify perceptions of how integration may occur within the technology education, science and mathematics curricula, and the fourth section represented selected actions that the technology education profession may take to improve the perceptions of the discipline. Demographic information, necessary to form the basis for a comparative analysis of the respondent perceptions, was placed on the first page of the instrument in order to allow respondents an opportunity to answer the more objective questions prior to answering questions requiring more subjective analysis (Fink & Kosecoff, 1985). The demographic information requested included age, level of education, years of teaching experience, number of years at present school, and professional discipline area of expertise. The three groups of participants responded to identical statements concerning technology education characteristics presented on the instrument. The responses were made by marking each statement according to a five point Likert scale. Participant agreement or disagreement with each statement was coded on a Likert scale as follows: Strongly Disagree (1), Disagree (2), No Opinion (3), Agree (4), and Strongly Agree (5). The mean group score ranking of each statement was based on the following breakdown of the Likert scale: 1.000 to 1.499 - Strongly Disagree; 1.500 to 2.499 - Disagree; 2.500 to 3.499 - No Opinion/Neutral; 3.500 to 4.499 - Agree; and 4.500 to 5.00 - Strongly Agree. The 38 item questionnaire was mailed to a total of 462 teachers; 154 technology education teachers, 154 associated mathematics teachers, and 154 associated science teachers.

The Cronbach's Alpha Test and the Scheffe' analysis were used to establish reliability and internal consistency for the questionnaire and were utilized as a part of the pilot study with a resulting reliability index of .82.

Analysis of Findings

The results of this research were based on a 52 percent return of the mailed survey. The returned instruments represented 40 percent of the mathematics teachers, 45 percent of the science teachers, and 70 percent of the technology education teachers surveyed.

Along with descriptive data pertaining to the perceptions of the various characteristics associated with technology education, the exemplary technology education teachers and the associated secondary faculty (science and mathematics) perceptual responses were analyzed using a mixed model analysis of variance (ANOVA). The ANOVA identified the significant differences in perception within and between teacher responses and distinguished possible interactions between the groups. The mixed model analysis ANOVA used a 3 X 4 analysis (3 teacher groups X 4 categories of technology education characteristics) of data. These categories included: (1) a comparison of the mathematics, science, and technology education teacher perceptions of methods utilized in technology education; (2) a comparison of the mathematics, science, and technology education teachers perceptions of the curriculum content of technology education; (3) a comparison of the mathematics, science, and technology education teachers perceptions of need to integrate the three disciplines; and (4) a comparison of the perceptions of the associated faculties with regard to appropriate actions for the technology education discipline to take in order to affect change in overcoming stereo-typical attitudes and opinions of technology education. The interaction with the main effect of perceived characteristics was significant at the $p<.01$ level. Table 1 summarizes the results of this mixed model ANOVA, with $F=7.77$, $p<.01$. There was a significant statistical difference between the perceptions of the technology, science, and mathematics teachers. The significant interaction effect indicated that part of the differences in the main effect was caused by differences between groups of teachers and could not be accounted for by sampling error alone.

Table 1
Summary of Mixed Model Analysis of Variance
by Teacher Groups and Technology Education Characteristics

Source	df	SS	MS	F
Between Subjects				
Teacher Groups	2	83.22	41.61	28.11*
Error	235	347.82	1.48	
Within Teacher Groups				
Perception	3	29.84	9.95	32.74*
Interaction	6	14.16	2.36	7.77*
Error	705	214.18	.30	

* $p < .01$

To better illustrate the patterns of main effect differences in perception, the four categories of technology education characteristics were separated and analyzed using a one-way mixed model ANOVA.

Methodological Characteristics

The methodological characteristics section of the questionnaire sought to identify the perceived methods that were being used in the technology education programs analyzed in this study. Ten (10) items on the questionnaire were devoted to this section. Mean representations indicated that the majority of the teacher evaluators agreed that the methods identified on the questionnaire were used in the technology education program. See Table 2 for a breakdown of each of the designated methods and descriptive data regarding each method characteristic. A further analysis of the teacher groups, however, indicated that technology teachers had a significantly higher estimation of the methods that were being used in the technology education programs in comparison with the mathematics and science teachers, F=26.19, p<.01 (see Table 3 for an ANOVA on teacher groups and method characteristics). The Tukey HSD test of significant F value indicated that there was a significant difference (difference = .72, p<.01) between the technology teachers and the mathematics teachers and a significant difference (difference = .64, p<.01) between the technology teachers and the science teacher mean scores. Both the science and the mathematics teacher groups perceived that the utilization

Table 2
Perceived Technology Education Teaching Methods

	Technology (*n*= 107)		Science (*n*= 69)		Math (*n*= 61)	
Topic	X	SD	X	SD	X	SD
Emphasis on problem solving	4.62	.65	3.90	1.00	3.79	1.16
Provides exploratory activities	4.69	.54	4.19	.67	4.23	.95
Instruction is goal oriented	4.17	1.03	3.74	.83	3.86	.99
Cooperative learning encouraged	4.17	.76	4.09	.68	3.92	1.05
Verbal activity emphasized	3.93	1.02	3.36	.95	3.08	1.08
Cognitive strategies developed	3.86	.93	3.07	.98	3.13	1.03
Interdisciplinary activities	4.38	.84	3.78	1.01	3.55	1.10
Broad range of assess. strategies	4.44	.82	3.64	1.01	3.57	1.08
Lessons are hypothesis driven	3.47	1.01	3.13	.90	2.97	1.02
Activity oriented laboratory inst.	4.12	.61	3.91	.10	3.89	1.15
Grand Means	4.22		3.68		3.60	

Table 3
Summary of Technology Education Teaching Methods
One Way Mixed Model Analysis of Variance

Analysis of Variance

Source	df	SS	MS	F
Between	2	27.34	13.67	26.19*
Within	235	122.67	.52	

Tukey HSD Test

Comparison	Difference
Technology Education vs. Mathematics	.72*
Technology Education vs. Science	.64*
Mathematics vs. Science	-8.40

* $p < .01$

of the methodological characteristics within the technology programs to be significantly lower than those of the technology education teachers, therefore exemplifying the perception problem external to the profession.

Table 4
Perceived Curriculum Content Characteristics of Technology Education

	Technology (*n*= 107)		Science (*n*= 69)		Math (*n*= 61)	
Topic	X	SD	X	SD	X	SD
Content is uniquely technological	4.28	.87	3.35	1.12	3.26	1.12
Based on know.of tech. develop.	4.43	.74	3.51	.98	3.39	.10
Based on the use of biological organ.	3.52	1.22	2.61	.10	2.84	1.16
Based on transferring information	4.44	.82	3.90	.75	3.73	.94
Based on modifying resources	4.56	.57	3.62	.84	3.53	.78
Based on the study of transportation	4.51	.71	3.26	.97	3.74	.81
Assists students in developing insight	4.69	.59	4.03	.82	3.98	.95
Apply tools, materials, processes	4.67	.63	4.28	.75	4.00	1.02
Aids in develop. of individ. potential	4.65	.60	3.77	.97	4.05	.97
Aids develop. of prob. solving skills	4.71	.55	3.78	.91	3.87	.97
Prepares students for lifelong learning	4.68	.58	3.64	1.03	3.90	.97
Utilizes math and science skills	4.54	.62	3.81	.96	3.89	1.12
Allows connect. of math & science	4.50	.74	3.65	.92	3.68	1.27
Grand Means	4.48		3.63		3.68	

Curriculum Content Characteristics

Data regarding the perceptions of the curriculum content characteristics for technology education were secured from the three teacher groups. Thirteen (13) items on the questionnaire were designated for this section. Table 4 depicts a complete categorization analysis of the teacher groups' appraisal of the perceived curricular content being used in technology education. Mean representations again indicated that the majority of the teachers within the three teaching disciplines agreed that the curriculum content was being appropriately utilized within the technology programs being evaluated. An ANOVA was conducted to compare the differences between the teacher groups relating to perceived curriculum content. A significant difference was found between these groups, F=53.63 $p<.01$ (see Table 5). A further analysis using the Tukey HSD test of significant F value indicated that there was a significant difference in the perceptions of the curriculum content between the technology education faculty and the mathematics faculty (difference = .80, $p<.01$) and a significant difference between the technology teachers and the science teachers (difference = .85, $p<.01$). Again, both the science and mathematics teacher groups discerned that the specified curricular content of the technology programs was utilized significantly less than was perceived by the technology education faculty, implying that either the curricular content was not as strong as indicated by the technology education teachers or that the curricular content was not perceived to be as strong.

Table 5
Summary of Curriculum Content Characteristics for Technology

Education - One Way Mixed Model Analysis of Variance

Analysis of Variance

Source	df	SS	MS	F
Between	2	39.80	19.90	53.63*
Within	235	87.19	.37	

Tukey HSD Test

Comparison	Difference
Technology Education vs. Mathematics	.80*
Technology Education vs. Science	.85*
Mathematics vs. Science	5.00

* $p < .01$

Perceptions of Integration Needs

The integration needs referred to the teacher groups' perceptions of how the technology education discipline could/should integrate with science and mathematics disciplines to better serve students. Five (5) items on the questionnaire were designated for this section. Again, there was general agreement among the teacher groups concerning the need for integration of the three disciplines (see Table 6 for item and group analysis). However, an ANOVA of the three teacher groups indicated that there was a significant difference in the perceptions of the need to integrate technology education with science and mathematics, F=26.31, p<.01 (see Table 7). Further analysis, using the Tukey HSD test of significant F value indicated that the differences between teacher groups were similar to the methodological characteristics and the curriculum content characteristics with a significant difference in the perception of integration between the technology teachers and the mathematics teachers (difference = .66, p<.01) and a significant difference between the technology teachers and the science teachers (difference = .69, p<.01). As stated in the methodological characteristics and the curriculum content characteristics, both the science and mathematics teacher groups determined that the in-

Table 6
Perceived Integration Needs of Mathematics, Science, and Technology Education

	Technology (*n*= 107)		Science (*n*= 69)		Math (*n*= 61)	
Topic	X	SD	X	SD	X	SD
Provides ave. for applying concepts	4.70	.52	4.04	1.01	4.15	.93
Should be available for all M/S stud.	4.84	.52	4.00	1.14	4.02	1.02
Tech. Ed. is an applied science	4.54	.76	4.12	.92	4.08	.98
Curriculum reflects ind. & tech.	4.43	.74	3.86	.97	3.71	1.22
Guided by tech. literacy needs	4.36	.70	3.42	1.22	3.61	1.16
Grand Means	4.57		3.91		3.89	

Table 7
Summary of Integration Needs for Technology Education
One Way Mixed Model Analysis of Variance

Analysis of Variance

Source	df	SS	MS	F
Between	2	26.82	13.41	26.31*
Within	235	119.78	.51	

Tukey HSD Test

Comparison	Difference
Technology Education vs. Mathematics	.66*
Technology Education vs. Science	.69*
Mathematics vs. Science	2.60

* $p < .01$

tegration needs for technology education with science and mathematics were significantly less than what were perceived by the technology education teacher group. This may suggest that the technology education teacher group was addressing the integration movement more adequately than the mathematics and science teacher groups.

Action Plans

The action plan segment of the questionnaire was designed to identify strategies and activities that may lead to improving the overall impression of the technology education discipline. Five (5) items were used to solicit the perceptions from the teacher groups pertaining to plans of action that may be helpful in improving the understanding of technology education (see Table 8). The technology education, science and mathematics faculty groups indicated that they were in general agreement with the specified action plan items on the questionnaire. An ANOVA was conducted to determine if the differences in perceptions was statistically significant; the recorded F value was not significant, F=1.73, $p>.01$ (see Table 9).

Table 8
Perceived Action Plans to Improve Perceptions of Technology Education

	Technology (*n*= 107)		Science (*n*= 69)		Math (*n*= 61)	
Topic	X	SD	X	SD	X	SD
Form interdisciplinary committees	4.48	.65	4.03	.94	4.13	1.06
Revise curriculum strategies	4.33	.77	4.19	.91	4.18	.97
Make presentations at nat. conf.	4.47	.74	4.28	.86	4.07	.94
Conduct research on integration	4.34	.84	4.17	.80	4.29	.95
Dev. strat. to overcome stereo-types	4.74	.60	4.12	.51	4.21	.99
Grand Mean	4.47		4.16		4.17	

Table 9
Summary of Action Plans to Improve Perceptions of Technology Education - One Way Mixed Model Analysis of Variance

Source	df	SS	MS	F
Between	2	3.42	1.71	1.73
Within	235	232.36	.99	

* $p < .01$

The perceptions of the teacher groups indicate that there were significant differences in each of the four categories, except the plans for action to improve the image of technology education. The technology teachers were consistently higher in their perceptions ranking on each of the categories. This again, suggests that the science and mathematics teachers do not understand the technology education movement or they do not generally agree with its overall scope and purpose.

Interactions

Table 1 reported that the interaction between independent variables (teacher groups) was significant (F=7.77, p<.01), suggesting that part of the differences in the significant main effect was due to differences between the three groups of teachers. After discovering the significant interaction, the four categories of technology education characteristics were plotted across the independent variables of the technology education, science, and mathematics teachers. The plot line slope is indicative of a significant interaction effect (see Figure 1), and, because it is rather flat, a simple main effects comparison was performed. This post-hoc comparison indicated a significant interaction for each line across the four categories of characteristics. The simple main effects post-hoc comparison is summarized in Table 10.

Figure 1. Post-hoc interaction comparison of technology, science, and mathematics teachers

Table 10
Summary of Simple Main Effects Comparison of the Significant Interactions Between Mathematics, Science, and Technology Education Responses

Source	df	MS	F
Technology Ed. & Science	3	1.15	3.80*
Science & Math	3	7.77	25.55*
Technology Ed. & Math	3	11.68	38.44*

* $p < .01$

Conclusions

Research Question One

In looking at the findings related to research question one, an analysis of the data revealed that, as a group, exemplary technology education teachers strongly agreed with the characteristics identified with technology education. This result held true for the three categories of characteristics: technology education methodology, technology education curriculum content, and the need to integrate the disciplines of mathematics, science, and technology education. The data revealed that the exemplary technology education teachers perceive the need for action to overcome stereo-typical perceptions as critical. Technology education was perceived as providing exploratory activities which emphasize problem solving through the utilization of small and cooperative group activities. Technology education was further perceived as a discipline which develops student insight, understanding, and application through technological study. The respondents indicated a strong need for integrating the discipline as well as utilizing mathematics and science concepts towards the preparation of lifelong learning skills.

Research Question Two

An analysis of the data revealed that, as a group, secondary mathematics and science teachers moderately agreed with the characteristics of technology education. While the mathematics and science teachers agree that these are characteristics of technology education, they do not strongly agree with any of the four categories of characteristics. At the same time the mathematics and science teachers perceived interdisciplinary instruction, activity based laboratory instruction, and problem solving to be characteristic of technology education, they do not perceive technology education as a discipline in which cognitive strategies have been clearly developed, or where lessons are hypothesis driven. These two groups perceived a curriculum where application of insight and understanding of tools, materials, and processes in production and communication are characteristics of technology education. Similarly the mathematics and science teachers characterized the development of creative abilities through problem solving and the enhancement of decision making skills as being fundamental to technology education. The use of mathematics and science skills and the connection between mathematics, science, and technology education were also perceived as a characteristic of technology education. However, the mathematics and science teachers did not perceive the study of the development of technology, biological systems, and transportation as being characteristic of technology education. There was agreement for the need to integrate mathematics, science, and technology education. However, the need for integration was not strongly agreed upon. As with the exemplary technology education teachers, the mathematics and science teachers perceived a strong need for the technology education discipline to develop strategies to overcome stereo-typical perceptions often held by associated faculty members.

Research Question Three

The findings reveal that there was a significant difference between the perceptions of the exemplary technology education teachers and the perceptions held by the teachers of mathematics and science. The findings were based on the mixed model ANOVA results and post-hoc examination. The significant interaction implied that the difference between group mean scores was due to differences between technology education, mathematics, and science teacher perceptions. Interpreting the findings as a whole, the results indicate that the characteristics perceived to exemplify technology education are not constant across all three disciplines. Exemplary technology education teachers strongly agree with the identified characteristics, while the mathematics and science teachers had significantly different perceptions of the characteristics which exemplify technology education.

Implications and Recommendations

The overall results indicate that the characteristics perceived to exemplify technology education are not constant across disciplines. The technology education discipline has a definite need to alter the image it projects in order to improve the overall perception of what technology education is, what it hopes to accomplish, and how it fits within the general education curriculum of primary, middle/junior high, and secondary schools. To understand the critical nature of this issue, it must be recognized that the technology education teachers which were identified in this study were selected based on their expertise and exemplary approaches to technology education within their schools (Wicklein, 1992). With this as a basis, the findings of this research take on a much larger impact. If associated faculties of these exemplary teachers of technology education identify the significant degree of disparity between perceived methods, curriculum content, and integration needs, then what can be expected from the rank-in-file teachers of technology education and their associated faculties? The issue of how technology education is perceived has influenced, and will continue to influence, the development of the technology education discipline.

Based on an interpretation of the data relative to this study, the following conclusions and recommendations were drawn:

1. The technology education profession should develop strategies to overcome stereo-typical perceptions of the discipline.
2. Technology education potential can not be fully reached until there is a clear understanding across disciplinary boundaries as to what characteristics exemplify technology education.
3. Technology education can more effectively emphasize the connections between mathematics, science, and technology education.
4. Coordinated planning that includes professionals from mathematics, science, and technology education is a critical component for the future of integrated curriculum among the three disciplines.
5. Workshops and presentations should be provided for mathematics and science teachers in an effort to improve their perception of the technology education discipline.
6. Further study should be conducted examining the public perception of technology education as a discipline in the secondary school.
7. Research should be conducted investigating methods of overcoming stereo-typical perceptions often held by associated secondary education faculty members.

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Enrollment Trends in Industrial Arts/Technology Teacher Education From 1970-1990

Kenneth S. Volk

The field of industrial arts/technology education (IA/TE) has gone through considerable introspection and revision over the past twenty years. This process has taken place at both the public school and post-secondary level. College and university programs which prepare industrial arts/technology education teachers have instituted changes in curriculum, program requirements, and facilities. Universities which prepare IA/TE teachers have also witnessed a change in emphasis and program support to non-teaching options such as industrial technology.

Considering these changes, what has been the overall effectiveness and relative strength of programs which have prepared IA/TE teachers? Since 1970, when the first university renamed and restructured their program from industrial arts to technology education (Lauda & McCrory, 1986), to 1990 was the period of time on which this study focused. The purpose of this study was to determine enrollment trends in technology teacher preparation programs. Specifically, the study examined data related to:

1. The number of degrees granted (by type) within technology teacher preparation programs.
2. The number of technology education degrees granted by universities with and without industrial technology programs.
3. Whether there was a significant difference in the technology teacher preparation enrollment trends of those universities with and without industrial technology programs.

An examination of such data would help gauge the current enrollment of teacher preparation programs, inform policy makers of the potential implications of program emphases, and encourage dialog about future trends and direction of the discipline.

Influences on Industrial Arts/Technology Teacher Education Programs

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There have been two broad influences on industrial arts/technology teacher education programs since 1970. One influence centers on the philosophical change from industrial arts to technology education, while the other involves the expansion of non-teaching options such as industrial technology (IT). The following discussion of these influences provides a basis for the IA/TE teacher preparation program trends assessed.

The philosophical change from industrial arts to technology education has involved the renaming of programs, the restructuring of courses, and changes in facilities. Since the first program name change to technology education in 1970, over 30 programs listed in the *Industrial Teacher Education Directory* (Dennis, 1990) now contain such a descriptor. Courses have been restructured, with traditional industrial arts content as woodworking and drafting being replaced or reconceptualized into manufacturing and communications. Facilities have also witnessed changes due to the philosophical and programmatic shifts to technology education. However, despite this apparent shift in program philosophy, by the end of 1988 only 23.7% of the programs reviewed under ITEA/CTTE guidelines for technology education had full or conditional approval (Weins, 1990).

The creation and expansion of non-teaching programs such as industrial technology has been recognized for its instrumental role in shaping the scope and emphasis of IA/TE teacher preparation programs. As discussed by Sinn (1989), the history and evolution of industrial technology programs was based on industrial arts education. The development of non-teaching IT options were due to faculty and administrative action at various institutions. Oaks and Loepp (1989) indicated this shift away from teacher preparation programs was a result of a desire by IA/TE-based departments to continue enrollments, while serving a new diversified population with different career goals. In this manner, students who did not enter the teaching profession after degrees in IA/TE were targeted in these new programs.

Oaks and Loepp also indicated the shift in emphasis toward nonteaching areas created problems with IA/TE programs nation-wide. They found IT program emphasis resulted in an erosion of support and recognition for IA/TE programs. With only 42% of the teacher preparation programs listed in the *Industrial Teacher Education Directory* (Dennis, 1990) being located in schools of education, matters of program attention and allegiance may be skewed. Bott (1988) provided an example of this reduced support. Bott compared vocational education programs located in schools of education with those located in schools of engineering or technology and concluded that in areas such as budgets, programs in schools of education received greater support.

Rudisill (1987) also noted the chaos and conflict caused by the factionalism between IA/TE and IT programs. He indicated technology educators no longer control the technical content courses, making the implementation of new recommended curriculum difficult. In this way, the IT spin-off from teacher education programs usurped the original program's mission and power.

The philosophical change from industrial arts to technology education and the expansion of non-teaching options have influenced programs which prepare technology teachers. It was determined an examination of industrial arts/technology program enrollment trends would help clarify questions as to the extent of such influences. Also, an examination of the past and present program indices would provide a base from which to project future program trends.

Methodology

To examine the enrollment trends of industrial arts/technology teacher education programs from 1970 to 1990, data contained in the *Industrial Teacher Education Directory* (Dennis, 1975; Dennis, 1980; Dennis, 1985; Dennis, 1990; Wall, 1970) was analyzed at five year intervals. Information within these sources included the number of industrial arts/technology education graduates; graduates with other degrees such as vocational education, industrial technology, and construction management; and faculty characteristics. The appropriateness of using directories for quantitative analysis related to IA/TE was demonstrated by Edmunds (1990), Moss (1989) and Wright (1986). Recognizing the limitations of basing historical trends on secondary sources (Isaac & Michael, 1987; Mason & Bramble, 1989), an attempt was made to minimize their effects on the integrity of the study. A main concern of using such data was the internal criticisms of document meaning and trustworthiness. Meaning refers to the way the document was interpreted; trustworthiness deals with the accuracy of the information provided.

The meaning of the categories of information provided in the *Directories* was of paramount concern to the author. Kaestle (1988) cautioned on the problems of examining certain educational variables that may have alternate definitions in different periods, or omitted from the report. Wall (1970), as compiler of the first *Directory* examined, also cautioned about this ambiguity when he stated “the listing of the major, because of different meanings attached to terminology, may not mean the same thing” (p. i). To increase the meaning of the *Directories*, the following steps were taken:

- Intra-directory differences in *Directory* labels were minimized with degree offerings divided into two broad categories: those involved with the preparation of teachers for general education programs in industrial arts/technology education, and those concerned with other vocational fields and non-teaching options.
- Inter-directory differences were minimized by comparing each institution's subsequent entry with the previous entry for changes in program name, degree classification, and program areas.
- Missing data for existing programs were estimated by the mean from the most prior and subsequent directories, following the recommendation of Borg & Gall (1989).

The trustworthiness of the secondary historical documents was also recognized as an important concern. Best & Kahn (1989) noted the relative worth or accuracy of such documents and asked whether the writers of secondary sources were competent, honest and unbiased. This study recognized that the information provided by the various departments listed in the *Directory* did not necessarily guarantee honesty nor accuracy. It was also quite possible that some of the information provided by universities may imply program strengths and hide program deficiencies by creative use of numbers. For instance, faculty numbers may include adjunct or emeriti professors, leading to the assumption of full-time positions. To increase the trustworthiness of the *Directories,* the following action was taken:

- When inter-directory inconsistencies appeared, such as when total program graduates increased dramatically while faculty numbers declined, an attempt was made to check the validity of the data (Englehart, 1972). Eighteen programs were identified as having such inconsistencies. A letter was then sent to a professor listed commonly in the first and last *Directories* requesting verification of the numbers for their programs. Eighteen respondents (100%) confirmed or amended the information.

Findings

Between 1970 and 1990, universities with industrial arts/technology education programs experienced considerable change in the number and type of degrees granted. Based on the data reported in the *Industrial Teacher Education Directories* in five year intervals from 1970 to 1990, several broad trends were observed. The findings are provided in the following sections.

University Programs

Table 1 provides information on the number of graduates from universities which offer programs in industrial arts/technology education. The total number of universities identified in the *Directory* providing programs in IA/TE decreased 14.7% from 1970 to 1990. When the number of universities reporting no bachelor degrees awarded for their program in the 1990 *Directory* is included, the resulting decline of universities producing IA/TE teachers since 1970 was 24.1%.

Table 1
Graduates From University Departments Which Offer Programs in Industrial Arts/Technology Education

		IA/TE Degrees				Non-IA/TE Degrees
Year	*n*	BA/BS	MS/MEd	EdD/PhD	Total	Total
1970	203	6368	1767	83	8218	894
1975	204	6371	1918	75	8364	1478
1980	205	5048	1353	73	6474	1453
1985	198	2668	931	51	3650	7725
1990	174	1790	650	50	2490	7063

The number of graduates prepared to enter the teaching field also decreased dramatically during this time. Between 1970 and 1990, there were 71.9% fewer bachelors degrees awarded, 63.2% fewer masters degrees, and 40.0% fewer doctorates. The rate of decline for all IA/TE majors was 69.7%. However, non-IA/TE degrees increased by 790.0% (87.4% fewer non-IA/TE degrees were awarded in 1970 than in 1990). This latter increase was due in great part to the explosive growth and shift in emphasis to industrial technology program options. Despite the decreased numbers enrolled in teaching programs, the shift to non-IA/TE options appears to maintain the number of total students enrolled in such university programs. Figure 1 shows the general trends of graduates with IA/TE and non-IA/TE options as well as total enrollments from universities with programs in industrial arts/technology education.

Figure 1. Degrees granted (by type)

Effects of IT Programs on IA/TE

To examine the effect industrial technology (IT) options had on IA/TE programs, the number of IA/TE graduates from universities with IT programs were compared with those that do not. The 1990 *Directory* descriptors for each university were used to identify and categorize such program offerings. Table 2 shows the graduation rates for IA/TE majors from these two program designs.

An examination of the IA/TE graduation rates from 1970 to 1990 found that programs without the IT option declined 52.9%; while those with the IT option declined 72.7%. It is interesting to note that during a similar time period, undergraduate education degrees for all disciplines decreased 54.9%, (*Digest of Education Statistics*, 1991) very similar to programs without the IT option.

Table 2

Industrial Arts/Technology Education Graduates From University Departments With and Without Programs in Industrial Technology

	Year						
Program	1970	1975	1980	1985	1990	(N)	%Dec.
IA/TE With IT	5812	5781	4349	2156	1586	(123)	72.7
IA/TE Without IT	1914	2136	1990	1487	901	(73)	52.9

The student means from programs with and without the IT option were examined. These data were used to further define the trends between the two programs. Table 3 shows the means and standard deviations for IA/TE students and non-IA/TE students from universities which offer the IT program option.

These data indicated the change in student numbers was not equal between the two groups. In general terms, the mean number of IA/TE graduates decreased, while the non- IA/TE graduates increased.

Table 3
Means and Standard Deviations of Graduates From Programs With the Industrial Technology Option

	IA/TE Students			Non-IA/TE Students		
Year	*M*	*SD*	*n*	*M*	*SD*	*n*
1970	51.2	43.6	113	13.5	16.2	31
1975	50.0	45.6	115	23.9	26.9	39
1980	36.8	37.5	117	23.8	31.5	43
1985	18.0	21.6	119	65.3	80.2	105
1990	13.3	18.5	119	56.9	71.9	113

Table 4 shows the means for graduates from university programs with no IT option. These data indicated that from universities which do not offer IT program options, there were both fewer IA/TE graduates and non-IA/TE graduates.

Table 4
Means and Standard Deviations of Graduates From Programs With No Industrial Technology Option

	IA/TE Students			Non-IA/TE Students		
Year	*M*	*SD*	*n*	*M*	*SD*	*n*
1970	29.9	29.2	59	22.1	21.2	18
1975	31.9	30.9	61	22.4	23.4	20
1980	29.5	26.4	64	14.2	10.1	22
1985	22.5	27.0	64	19.9	18.4	35
1990	14.0	18.7	64	17.6	19.4	33

To determine if there was a significant difference in the magnitude of change between the number of students graduating from the two types of programs (with IT program option, no IT program option) from 1970 to 1990, a one-way analysis of variance (ANOVA) based on a split plot factorial design (Kirk, 1982) was performed. The dependent variables of IA/TE graduates and non- IA/TE graduates were used for this procedure. A contrast/contrast interaction was also performed for the years 1970 and 1990.

The ANOVA summary table with IA/TE graduates as the dependent variable is presented in Table 5. A significant difference was found between the university programs with and without the IT option (F 1,704 =20.96, p=.0001).

Table 5
ANOVA Summary Table With the Log of IA/TE Graduates as the Dependent Variable

		SSQ	F	p
Type	1	3.02	9.18	.0025
error	181	591.49		
Year	4	190.60	144.81	.0000
Year*Type	4	16.51	12.54	.0001
error	704	231.64		

The ANOVA summary table for non-IA/TE graduates as the dependent variable is presented in Table 6. A significant difference in the change in enrollment (graduates) was also found between the two programs (F 1,293 =51.99, p=.0001).

Table 6
ANOVA Summary Table With the Log of Non-IA/TE Graduates as the Dependent Variable

		SSQ	F	p
Type	1	0.34	0.61	.4352
error	156	410.74		
Year	4	28.75	13.07	.0001
Year*Type	4	37.81	17.19	.0001
error	293	161.16		

Conclusions

The conclusions of this study were derived from the findings and are dependent on the limitations noted for document meaning and trustworthiness. This study indicated five general trends:

1. The number of universities offering IA/TE programs has decreased since 1970.
2. The number of graduates prepared to enter the teaching field as industrial arts/technology education teachers has declined.
3. The number of non-IA/TE majors graduating from expanded programs areas such as industrial technology has increased, resulting in fairly constant total student numbers for university departments.
4. The decline in IA/TE graduates from universities which do not offer industrial technology program options was consistent with the national trends for all areas of teacher education.
5. The decline in IA/TE graduates from those universities offering industrial technology programs has been significantly greater than those that do not offer such options.

Implications

Considering the observed trends in program numbers and options, the future growth, success, and very existence of many university programs which produce IA/TE teachers is in doubt. There are several reasons for such skepticism.

Program Strength

The data indicated a trend toward fewer students interested in becoming IA/TE teachers. This trend is not salient to only IA/TE professionals. Poor working conditions, job stress, and poor salaries have been identified as contributing factors to attracting and retaining teachers from all subject areas (Metropolitan Life, 1985). However, given the alternate opportunities available to IA/TE majors with non-teaching options, the similarities with other specific subject areas which have recruitment problems: i.e., science and mathematics, is evident. Science and mathematics have allies in their role as a necessary component in public educational institutions, whereas IA/TE has not been championed to the same extent. The trends indicated that the few students enrolling in IA/TE teacher preparation programs may not justify the continued existence of programs despite their past popularity and health. The current economic conditions facing many universities may also exacerbate the demise of these programs.

Program Compatibility

The change in emphasis and growth of IT offerings may be in conflict with the established role and mission of universities that once had a traditional emphasis on teacher preparation. Again, political and economic considerations may have university administrators examining the continuation of such non-teaching programs. Should the now-dominant IT programs which exist in many universities belong in the College of Education, or does the teacher education component belong in a College of Technology; divorced from their pedagogical counterparts? Already, shifts in departmental structure can be observed in universities, with technical components being separated from the teacher preparatory component. Programs at institutions such as East Carolina University and Georgia Southern illustrate this trend. With this separation, IT programs have formed their own identity and justification for existence, independent from the pedagogy of IA/TE.

Program Viability

The technical component of university IA/TE programs which increased their emphasis on IT may be in competition with other programs or those technical programs within the university, or offered at the community college level. In the former situation, IT may not automatically be considered an engineering discipline, thus being in conflict with those universities having established engineering programs. If one mission of an IT program is to develop middle-management and technically-competent individuals for areas such as construction management and manufacturing technology, then it is quite possible the facilities and opportunities available through community colleges may adequately address these needs. The new emphasis in federal funding for 2+2 programs and Tech Prep may further accelerate the position of community colleges to deliver state-of-the-art technologies. With this scenario, university IT programs may find themselves concentrating on students only in their last two years of a bachelor's degree.

An ancillary issue stemming from the diminished importance of preparing teachers through the technical component of IT programs relates to the quality and relevance of the technical subject matter. If the adage “you teach as you were taught” has any credence, then many of the technical courses received through IT-centered programs are philosophically and contextually incompatible with current technology education programs suggested for secondary schools. Evans (1988) concurred, stating “a curriculum designed for prospective technologists and engineers seldom provides the content which prospective teachers need to teach” (p. 144). IA/TE centered technical courses which had pedagogical strategies and activities for future teachers of the subject may be of diminished importance or necessarily eliminated from IT-centered courses. For example, activities such as preparing and presenting a lesson to the class, or designing a project/activity for secondary schools might be a requirement in technical courses in which teaching the subject of technology was the prime focus. Hatch and Jones (1991) discussed this practice when they described the

IA/TE teacher preparation programs of the 1960s and 1970s. They stated that "to a large degree, teacher educators taught technical content and, not surprisingly, they frequently incorporated instruction about key aspect [*sic*] of teaching methodology within their technical courses" (p. 240). In this manner, valuable examples and experiences directly related to the profession of teaching are missing from technical courses designed for an IT curriculum, resulting in less qualified individuals being prepared or skilled in the art of teaching technical subjects.

Program Attractiveness

If the change of industrial arts into technology education is an evolutionary process (Clark, 1989; Kuskie, 1991; Wicklein, 1991), then the type of student preparing to be a technology educator may not be the same as before. Henak and Barella (1986) alluded to this qualifier when they stated that in order to develop the new and different competencies of technology education, "a new kind of teacher" is required (p. 167). Miller, R. (1988) commented on the ability of university technology education programs to attract students after observing trends for over a decade in his *Annual Survey of Industrial Arts Teacher Supply and Demand*. He stated:

> It took industrial arts about 30 years to replace manual training and manual arts as a name in the public schools and in the mind of the public that supported the schools. The many areas such as woodworking, drafting or mechanical drawing, power and transportation ... were well-known and in most instances well-taught. (p. 14)

Miller further stated:

> Needless to say, by now, everyone realizes that the changing of a name means there are some problems. The recruiting of young men and women into the teaching profession is difficult enough these days, but the changing of the name into something else makes it even harder to recruit when you have to tell the prospective professional that the name of the profession he/she is interested in has changed its name and direction. (p. 14)

The lack of detailed descriptors from the *Directory* listing specific course content prohibited an analysis of trends between those university programs continuing to provide traditional industrial arts courses with those that ceased. Further study needs to be conducted in this area.

Summary

The examination of the enrollment trends in industrial arts/technology teacher education programs from 1970 to 1990 indicated several broad trends: (a) university programs and student enrollment numbers continue to decline from the 1970 levels, (b) graduates with non-teaching degrees such as industrial technology has increased, and (c) universities with accompanying industrial technology programs have witnessed a significantly greater percentage decrease in technology education enrollment than those universities that do not. The implications from these trends addressed issues such as program strength, compatibility, viability and attractiveness.

Considering the declining number of post secondary industrial arts/technology education graduates and the implications for the profession, it is imperative further discussion and studies be conducted, including the following:

- What are the projected future trends and program changes for universities? How many of the programs fear closure due to declining budgets or enrollment?
- How have faculty numbers and qualifications influenced the programs? Faculty research emphases and recruitment should be part of this discussion.
- To what extent are secondary teachers encouraging their students to become technology educators? In a similar manner, with the curriculum changes that have occurred, would those trained years ago as industrial arts teachers become technology educators, had they to do it over again?
- Are the existing secondary IA/TE teachers accepting the change to technology education? Studies by DeLucca and James (1991) and Rogers (1991) have begun to address this issue.
- Have the teacher preparation programs which maintained traditional industrial arts courses been more, or less successful in recruiting students?
- Are the expectations of new students in post-secondary technology education programs consistent with the philosophies taught? In other words, do new students know what they are getting into with the changing curriculum?

If the 20-year enrollment trend illustrated in Figure 1 continues, the demise of the profession will occur near the year 2005. It is therefore hoped the findings and implications presented serve as a catalyst for more discussion on the health and direction of post-secondary industrial arts/technology education programs. With the continued decline in technology educators being prepared and the changing emphasis in program options, the very survival of the profession is at stake.

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British Design and Technology: A Critical Analysis

R. Thomas Wright

A great deal of interest has been shown in the British National Design and Technology Curriculum. A number of English Design and Technology education leaders have visited this country and a small group of American technology educators make periodic trips to Britain to observe the curriculum in action.

Many of the reports provided to Americans by these individuals suggest that the British have THE answer and that we are years behind the Brits (Bottrill, 1992). However, Americans who question the British model as the utopian answer are often dismissed as unenlightened conservatives trying to protect skill-based programs.

This paper is based primarily on a review of *Technology in the National Curriculum* (National Curriculum Council, 1990) and a trip to England. This trip included discussions with a shire (county) technology leader, an in-service technology teacher trainer, a technology equipment representative, and over 25 technology teachers who work at all educational levels from infant to secondary schools. The teachers covered the spectrum from one person resisting curricular change to a number of groups expending considerable effort to implement the national curriculum. The sample was not a hand-picked group of success stories designed to show the curriculum only at its best, but represented a reasonable cross-section of the teaching and leadership ranks.

The National Curriculum

The educational program that is often referred to as the British National Curriculum is actually the curriculum for England and Wales. It includes a number of subjects of which technology is one. The other two countries that make up the United Kingdom, Scotland and Northern Ireland, have their own curriculums with a uniquely different type of technology education. Therefore, for the remainder of this paper the curriculum being discussed will be the English and Wales technology education and will be referred to as the National Curriculum.

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The National Curriculum has evolved over time. A detailed historical description of each change, with the corresponding educational and political motives, is not appropriate for this paper. However a broad over-view provided by Wilson (1992), suggested that the evolution of post-war technology-related instruction can be seen in four major steps. The original post-World War II program was a series of separate studies in woodworking, metalworking, and technical drawing. This program was called *craftwork* and focused on using tools to build projects. This program was replaced in the 1970-1990 period by Craft Design Technology (CDT) which added design to the making emphasis of the craftwork program. Starting in 1975 problem solving was fused into the program that added evaluation to the designing/making emphasis of CDT. The final transition was the National Curriculum that was initially implemented in 1990.

The National Curriculum is a mandatory program for all state primary and secondary schools. It includes technology as a foundation (core) subject "which requires pupils to apply knowledge to solve practical problems" (National Curriculum Council, 1990). The subject of technology, according to Layton (1991), merged two separate subjects that were in the schools: CDT and home economics. Technology is divided into two components: design and technology capability and information technology capability. Information technology is seen as cross-curricular and is recommended to be taught as an integral part of all foundation subjects including technology.

Design and technology (D&T) is expected to be taught through themes and projects in the primary school and as a separate subject in the secondary school. D&T instruction is couched within home, school, recreation, community, and business and industry contexts and explores an interrelationship between environments, artifacts, and systems, Figure 1. These three elements, according to Hampshire Education (1990), are defined as follows:

- Environment: Surroundings made or developed by people.
- Artifact: An object made by people.
- System: A set of objects or activities that together perform a task.

D&T includes four basic areas: construction materials, food, textiles, and graphic media (London Borough of Barnet, 1992). Each of these areas focuses on four attainment targets (AT) which are the major organizers of the curriculum. These targets and their objective are described by the National Curriculum Council (1990) as follows:

AT1 - Identifying Needs and Opportunities

"Pupils should be able to identify and state clearly needs and opportunities for design and technological activities through investigations of the contexts: home, school, recreation, community, business and industry" (p. 3).

AT2 - Generating a Design

"Pupils should be able to generate a design specification, explore ideas to produce a design proposal and develop it into a realistic, appropriate and achievable design" (p. 7).

AT3 - Planning and Making

"Pupils should be able to make artefacts, systems and environments, preparing and working to a plan and identifying, managing and using appropriate resources, including knowledge and processes" (p. 11).

AT4 - Evaluating

"Pupils should be able to develop, communicate and act upon an evaluation of the processes, products and effects of their design and technological activities and of those of others, including those from other times and cultures" (p. 15).

Each of these four attainment targets has ten levels that allow students to progress from simple to complex tasks as they move through their eleven years of required schooling. However the ten attainment levels do not necessarily correspond directly with the schooling years. Early levels use familiar contexts such as home and community and simple design problems. At advanced levels pupils explore more complex contexts while they are "given more opportunities to identify their own tasks for activity, and should use their knowledge and skills to make products which are more complex, or satisfy more demanding needs" (National Curriculum Council, 1990, p. 19).

For teaching purposes the levels are grouped into four Key Stages that have their own program of study (PoS). These programs list knowing and doing skills the students should learn and provide suggestions for activities under four major themes:

Figure 1. National Curriculum Model. [Adapted from London Borough of Barnet. (1991). *Design & Technology Design Cycle* (Transparency)]

- Developing and using artifacts, systems, and environments
- Working with materials
- Developing and communication ideas
- Satisfying needs and addressing opportunities.

At the end of each Key Stage the pupils are to be assessed using national criteria and examinations. These key stages with their over lapping attainment levels are as follows:

- Key Stage 1 - Levels 1 to 3 - ages 5 to 7
- Key Stage 2 - Levels 2 to 5 - ages 7 to 11
- Key Stage 3 - Levels 3 to 7 - ages 11 to 14
- Key Stage 4 - Levels 4 - 10 - ages 14 to 16

The relationships among the curriculum's four attainment targets, ten levels, four key stages and the programs of study are shown in Figure 2.

The exposure students have to technology varies among schools. Most secondary students have technology for two to three periods per week. These classes may be in materials, food, graphic media, or textiles. Formal class instruction (lectures, demonstrations, etc.) is minimal because the classes are organized around design briefs. The students are given a design challenge and are encouraged to seek appropriate information as they address the problems they encounter in developing their solutions.

The students are expected to document their work as they move through the four areas of needs and opportunities, generating a design, planning and making, and evaluating. The majority of laboratory work is completed with simple hand tools and very limited machine use. Most class activities seemed to be restricted to using paper, plywood, and hardboard because of the limited emphasis on producing devices and very small supply budgets.

Figure 2. Structure of the National Curriculum

Critique

The challenge for all critical reviews is to identify the strengths and weaknesses of the program being evaluated. The following is this author's list of the key points gleaned from a review of the National Curriculum materials, visits to schools in the London and Sheffield areas, and criticisms leveled by those English leaders outside the design and technology education arena.

Strengths

Technology is designed for all children regardless of age, gender, or career aspirations. The broad clientele for which the *Technology in the National Curriculum* was developed makes it a universal study of an important phenomenon in society. The students at all levels of schooling study technology and are assessed at the end of each of the four key stages. Male and female students work cooperatively and without the attitude that making things with tools are for boys and cooking is for girls that is somewhat common in the United States.

Technology integrates a number of school subjects under a single area The National Curriculum was developed to meet the needs of all students in England and Wales. It includes instruction that was previously taught in home economics; business studies; art and design; information technology; and craft, design, and technology. This broad scope is unique, according to Layton who wrote, “never before has an attempt been made to teach D&T to all children . . .”

Weaknesses

The design process does not provide clear definition for the area of study. The National Curriculum is a process-based program that uses the design process as the vehicle to organize its content. The students engage in a continuing array of design problems as they progress through the various levels of schooling. They identify opportunities, generate designs, build prototypes, and evaluate the design. However, the News (1992, p. 3) reported the criticism of the design process that was leveled by Robison and Smithers. The critics suggested that in using the design process alone most activities become technology - writing a report, conducting a scientific experiment, finding one's way to a railway station. This breadth of the subject had led to a loss of focus that is a major area of concern of the critics of the program. According to a report in The Engineer (Council, 1992) the focus of the program “has turned from being a 'designing and making' subject based on science and maths into generalised problem-solving without a specific knowledge base . . .”

The program fails to address commercialization of designs to meet human needs and wants. With the primary focus on design, students seldom consider commercialization of the design. The third attainment target, planning and making, has been interpreted by most teachers as modeling and therefore little attention is placed on the processes used to make the technology available to people. For example, a group of students in one school was challenged to design the communication media for a rock concert. They developed posters, cassette recording covers, programs, and sweatshirt designs. However, they did not study the process that could be used to produce these items in quantity nor did they progress past the pen and ink, magic marker, or poster paint model stage. Criticism of this sole reliance on the design process has recently appeared in the popular press. Smithers (1992, p. 16), in a Daily Telegram article, suggested that “technology is about making things - not just planning and design.”

Technology is often broadly interpreted as a study of any system that meets human needs. The National Curriculum studies environments, artifacts, and systems. As stated earlier, a system is described as any set of objects or activities that together perform a task. This definition has allowed some people to study any system that is used by people. For instance, Wilson (1992) suggested that the political system is within the purview of study for technology. The failure to associate technology with technical means has made technology, according to Robinson and Smithers (1992) , so general; that no one can define it.

Technology as defined by the National Curriculum lacks a clear mission. The National Curriculum, in merging home economics, art and design, business studies, and CDT, caused the mission to lose focus. The original intent was to empower people by helping them “understand and control one of the most powerful influence on society . . .” (Layton, 1991, p. 1). However, as Smithers (1992, p. 16) suggested in the Daily Telegraph article, this goal has been confused by allowing two basic experiences that overlap technology to be infused into the curriculum. They are basic life skills and vocational education. He suggested “An important purpose of schooling is to give children practical skills. Among these are a number which are affected by technology but not necessarily part of it. For example being able to cook, use a word processor, or fill in forms. These are all important . . . but to treat them as technology runs the risk of their becoming intellectualised [knowledge devoid of practical application].” Robinson and Smithers were reported in the *News* to have clearly presented the problem of curriculum focus when they suggested *The problem with technology can be stated very simply: it lacks identity.* The first step in focusing the program, according to these critics, is to “delimit it as a subject saying what technology is and, just as important, what it is not” (Problem of technology, p. 3).

Information Technology is in reality computer skills. The original intent of the information technology was to develop pupil's ability to communicate and handle information, design and model real and imaginary situations, and measure and control physical variables and movement. This would suggest the study of electronic and graphic communication and fluidic, electrical, and mechanical control systems. However in practice, the area of information technology quite often focuses on using computers in graphics, word processing, charting, and spreadsheets. Many schools have separate computer labs where this work is done. There was little evidence that computers are an integral part of design technology. Likewise, the study of control systems seems have been lost in the transition from CDT to D&T.

The National Curriculum document and structure are abstract and difficult to understand. The curriculum guide is a legal document that lists attainment targets and levels and presents brief outlines for programs of study for each of its four key stages. The document is a maze of terms, lacks a clear teaching plan, and fails to communicate its focus adequately. For example, Layton (1991) suggested that the four attainment targets that appear to be steps in a design process are not meant to define a process. Instead, he suggests that “they should be seen as a series of windows into the interactive processes of D&T through which information useful to teachers about the performance of their pupils can be obtained” (p. 5). Language like this provides little guidance to implementing teachers. Layton, further suggested “the achievement of the goals of Technology is not always helped by the necessarily legalistic description of attainment targets (ATs), statements of attainment (SoA) and programmes of study (PoS) . . .” (p. 1).

Implications for Technology Education in America

The National Curriculum is very different from most American technology education programs. First it is based on the concept that a national curriculum is superior to locally developed programs. It is also driven by national attainment tests that are used to measure student and program success.

Second the National Curriculum is based on the problem solving or design process while most American programs are content focused. The National Curriculum uses design problems with the intent of leading students to the knowledge of technology. The success of this approach is determined by the design problems used and the expectations teachers have for their students. In contrast most American programs have identified content and then use a combination of design and processing activities to make the content easier to understand.

The lack of a clearly communicated educational program and the loss of focus for technology in the National Curriculum was evident to this author. It also was apparent to a number of influential leaders in England. Smithers (1992) asked, "What is wrong with technology is schools? Almost everyone thought it was a good idea to make it part of the national curriculum. But now, teachers are confused, pupils spend their time on unlikely activities, such as compiling folders on keeping fit" (p. 16)

In response to a tide of criticism, John Pattern, the Education Secretary, ordered "an urgent review of technology in the national curriculum." That this action was taken because, after observing 2613 lessons in 884 schools, Government inspectors found 40 per cent of technology lessons in the secondary schools and more than a third of those in primaries were unsatisfactory (Technology Criticised, p.1). Ward further reported that the action will result in "the first complete shake-up of a national curriculum subject and is in response that too many pupils are offered a 'Blue Peter' approach to technology." (Blue Peter is a British television show where paper, sticks, and other simple materials are used to superficially present scientific principles.)

Pattern (1992) told the House of Commons that the revision is to raise the teachers' expectations of the pupils, specify more clearly the skills and knowledge that the pupils should acquire, give more emphasis on the practical element of the subject, and improve the manageability of the curriculum in the classroom.

Americans have a lot to learn from the National Curriculum experience. First, we need to focus more effort in making technology education available to all students, male and female, at all levels of schooling. We have failed miserably in getting technology recognized as important content for all students, K- 12, and at attracting female students in appropriate numbers.

Second, we need to address more fully the design and development processes used to create technology. This should involve cooperative learning and open-ending design challenges. However, enlarging our focus must be done without loosing the processing component of our program. Our programs need hands-on/minds-on experiences that help students understand how technology is created, produced, used, and assessed. We should not abandon the knowledge and action involved in producing technology and in selecting, using, and maintaining technological devices.

Third, we should keep in mind that technology exists only when technical elements are present. It does not include all systems or all application of resources to solve human problems. Nor does it include all applications of problem-solving techniques. For example, a marriage counselor applies knowledge as a resource to help solve family problems and may not use any technical means.

Fourth, we need to be cautious in defining technology so broadly that anything and everything fits under the description. Our definitions should clearly communicate what technology is and what it is not. We should resist the temptation of embracing the goals of developing life skills and vocational education as central missions for technology education.

Fifth, we should heed the advice that Bensen (1992) gave and, like the British, delete “education” from the name of our field . Students should study technology along with science, mathematics, language arts, and history. According to Bensen, those subjects that use education in their titles (i.e.; driver education, physical education, distributive education, consumer education) are generally perceived as less academically respectable and afforded less respect by educators and the public.

Sixth, we need to keep consider the audience when we write curriculum. The documents should be “teacher friendly” and very descriptive.

Finally, we need to learn from each other. Every country that has technology education programs have something to offer curriculum developers. Also often they have very different philosophical bases for their programs. The basic philosophical difference between the National Curriculum and American technology education (process versus content) makes the two programs almost impossible to compare and to determine “who's ahead of whom.” Making such a determination relies almost totally on judgments much like deciding if Michael Jordan's 35 points scored in basketball is superior to Tom Watson's five- under-par round of golf. In the end, such comparisons can be counterproductive by diverting the energies away from educational matters and toward emotional debates.

American technology education is grounded on a solid foundation and heritage. But like the field it presents to students, it must be ever-changing. Its scope and contents must always be examined and modified as time dictates. An evaluation of the British National Curriculum suggests that we should consider expanding the scope of the field to encompass more problem solving and design, more clearly delineate the mission of the field, and continue to develop high quality instructional materials and curriculum guides.

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Reactions

Diversity, not Uniformity United, not Standardized: A Reaction to Wright's “Challenge to all Technology Educators”

Stephen Petrina

“Conflicting conceptions of curriculum presuppose diversity in the underlying conceptions of education” (Sockett, 1976, p. 17).

In Volume 3, #2 of the *Journal of Technology Education*, Thomas Wright (1992a) began his “Challenge to all Technology Educators” by stating, with reference to diverse forms of industrial arts and allusions to a recurrence of similar diversities in technology education, that “educators seem to have a strong desire to relive historical mistakes.” (p. 67). As both a lesson from history and an alternative to curricular diversity, Wright proclaimed that now, “*the* challenge to *all* technology educators is to *apply the same logic* as science uses to determine the curriculum [italics mine]” (1992a, p. 68). His discomfort with diversity marked the remainder of his editorial (see also Wright, 1992b).

Before presenting arguments against Wright's contentions, three criticisms will be directed toward his curriculum model for “*all* technology educators.” One, Wright's model is devoid of references to contemporary scholarship in the field of curriculum studies, and represents a technical, disciplinary-based, and trivialized conception of curriculum processes. Problems like those evident in Wright's conception of curriculum have been critiqued in technology education (Herschbach, 1989; Zuga, 1989, 1991) but remain prevalent (Petrina, 1992b). Two, Wright's depiction of “science” as an exemplar of curriculum appears to be based on speculation related to the evolution and legislation of disciplinary subjects. My concern is not with the use of the sciences as curriculum exemplars, although that is questionable, it is whether Wright's reduction of curriculum processes in “science” to two linear steps is valid. Three, “the technological method” on which Wright's model leans, should be viewed

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as it is: a heuristic whose efficacy is limited to systems thinking. Methodological claims to “the technological method” are bereft of any epistemological grounding within the history, philosophy, or sociology of technology (Petrina, 1992a,1992b). Save for the lack of space to expand on those criticisms, Wright's challenge smacks of discipline envy and status quo.

My arguments against Wright's contentions will focus on two points. First, Wright's history lesson may be flawed in more ways than one. And second, implications of Wright's disciplinary challenge for “all technology educators” deserve serious attention.

My first disagreement with Wright is with his contention, as somehow justified through his example from the past, that “different positions [concerning ccurriculum] are dangerous” (p. 67). To paraphrase Wright, the lesson here is that in order to avoid reliving problems which were associated with curricular diversity in our past, we should all “apply the same logic... to determine the curriculum.” The following, different conclusion and lesson can be derived from the historical record: curricular diversity has been an historical fact of our profession, and problems with which it is associated can be overcome by recognizing a value in diversity.

Without digging too deeply through the historical record, most within our profession are keenly aware of the degree to which personality conflicts and claims of “the solution” tended to devalue inherent diversity. Nothing short of a miracle would have brought that community, to which Wright referred, to agree that “all” would “apply the same logic.” Like our chronological predecessors might have been, we may be a contentious, disagreeable bunch of consummate perfectionists. In which case, there's probably no real alternative to an embrace of our own inherent diversity.

Ignoring a remote possibility of innate contentiousness, and rather than an inability of “all” to “apply the same logic” in the past, a devaluing of diversity, for whatever reasons, may have been a more active mechanism underlying what appeared to Wright as confusing disunity. And, as opposed to confusing disunity, they, like us, may have been experiencing what Schubert (1986) called “productive uncertainty” (p. 8).

Also, more than an inability to effect uniformity in curriculum, our inherited diversities *and disparities* may be grounded in problems of sociological and philosophical drift (Petrina, 1992b). Hence, while Israel (1981, p.5) argued “that in the past 15 to 20 years, industrial arts... has become so diversified in its thinking that the profession has lost its sense of mission,” I'm arguing for a dialectical interpretation. Diversities and disparities that Israel and Wright had noticed were/are also symptomatic of a profession's eventual loss of a sociological mission, and failure to develop an inherited philosophical base. It may be productive to look into the past for constructs on which to unite, rather than as Wright suggested, toward disciplines. Otherwise, philosophical (i.e., *not* “what should be taught?” but “what epistemological meaning can we assign to experience... to action?”) and historical inquiry in technology education might as well remain, as the few who publish in these areas would probably agree, moribund. From this view, whatever “solid philosophical ground” Wright (1992a, p. 70) proposed for the profession of technology education is illusory. Perhaps it is time to revive historical and philosophical studies; and consequently, redo our histories of the profession and unite diversities through a recovered philosophy of experience and progressive sociological mission.

My second argument with Wright is related to his prescription for overcoming a persistence of historically shaped diversities. Wright's “challenge to all technology educators... to apply the same logic as science uses to determine the curriculum” reinforces a “one best,” disciplinary-based prescription for technology education (Petrina, 1992b). It may well be that credulous and uncritical views of curriculum underlie discipline envy in technology education. Still, some technology educators seem determined to acquire the stability, resources and status afforded through the disciplines (DeVore, 1992; Dugger, 1988; Savage & Sterry, 1990; Technology Education Advisory Council (TEAC), 1989; Wright, 1992a). Advocacies for a discipline of technology subscribe to “disciplinary doctrine” which holds that “the chief if not the sole criterion for including any subject in the school curriculum is whether that subject is recognized as an academic discipline” (Tanner & Tanner, 1989, p. 341). A corollary to disciplinary doctrine is: “curriculum planning demands attention to the logic of subject matter in order to identify what is educationally worthwhile” (McAleese & Unwin, 1978, p. 220).

A case can be made, with disciplinary doctrine and its corollary, that if technology was a discipline, *then* technology education would warrant an established place in the educational system. Inasmuch as technology educators may be in want of disciplinary status, “the trappings — a set body of knowledge, texts, and methodology” with which it is accompanied may be antithetical to larger goals (Disinger, quoted in Brough, 1992, p. 29). As Brough wrote of a similar dilemma for environmental studies, without “the trappings [of a discipline] this upstart field may continue to be dismissed... with these trappings, it risks becoming part of the discipline-bound tradition it is seeking to break” (p. 29).

Nonetheless, with little more than “yes it is — no it is not” style debate concerning a technology discipline, disciplinary frameworks for organizing curriculum have become idiomatic in technology education discourse and practice. Here is an interesting case where, over a short period, legitimating rhetoric became a type of reality for a group of professionals. Entertaining enough, disciplinary proposals validate the already codified and “one best” content systems of communication, construction, manufacturing, transportation, and reluctantly for Wright, bio-related and production.

Whether they are organized on disciplinary systems (DeVore, 1992; Hales & Snyder, 1982; Wright, 1992a) or disciplinary processes within a systems framework (Savage & Sterry, 1990a, 1990b), curriculum proposals which define a discipline of technology are driven by disciplinary doctrine. In other words, teach technology education because it is grounded in the technology discipline. Through Brough's reasoning, in exchange for resources and status of the disciplines, some technology educators are willing to forgo historical intentions of breaking traditions of disciplinary isolation and irrelevance.

Wright's challenge and his exclamation that “technology education is desperately trying to become a recognized, accepted discipline” are provocative (1992b, p. 3). Equally provocative is DeVore's (1992) conviction that “the search [i.e., research agenda for technology educators] *must be* for the structure of the discipline... *the rest is commentary* [italics mine]” (p. 31). DeVore's attempt to render voiceless alternative modes and avenues of inquiry, and epistemically close discourse on professional direction invites skepticism and criticism of the entire disciplinary agenda. Besides, DeVore's remarks and Wright's “challenge... to apply the same logic” are manifestations of a timeworn style in technology education which offered “one best” solutions at the expense of values such as diversity and discourse.

Those values are compromised when professionals within coalitions, albeit loose, begin to argue that their idea “must be” “the challenge” for “all.” Given inherent diversity, historical and sociological traditions, disciplinary proponents have prescribed a “one best,” ahistorical, and status quo idea. Turning Wright's concern toward his own disciplinary convictions, educators “must be” held accountable for their curricular actions and develop “defensible curriculum base[s]” (1992a, p. 67), which are sensitive to historical traditions and shared assumptions. The concept of diversity should not imply that technology education can be relative or ahistorical.

Given implications of a “discipline bound” profession, disciplinary proponents are obligated to present a persuasive argument, somehow free of disciplinary doctrine, for promotion of uniformity through their “one best” idea of curriculum and research. A clear explication of the reasoning which underlies suggestions that hopes of recovering a philosophical base of experience and progressive sociological mission should be relinquished. Another obligation is the presentation of a comprehensive, cogent reading of the technology discipline which remains partially defined (Petrina, 1992a, 1992b).

As Wright (1992a, 1992b) was correct in pointing out, there are a number of diverse, and often disparate, forms of technology education. But, there is little chance that we will all agree to, nor a legitimate reason why we should, “apply the same logic... to determine the curriculum” now or in the future. Perhaps only an embrace of diversity, and a recovery of a philosophical base and sociological mission can unite technology educators.

Diversity of existing programs associated with technology education can be articulated through a railway metaphor. With old engines worn but still rolling on the mainline, traffic has increased through the introduction of new engines designed by railway shareholders (see Figure 1).

Figure 1. Programmatic diversity of "technology" education within a context of "Technology" education.

Railway metaphor aside, are “Maryland Plan,” “conceptual framework,” “design & technology,” “modular framework,” “pre-? industrial arts” and “tech prep” differences in kind as opposed to degree of technology education? How defensible is disciplinary doctrine... it works... it's new? How inclusive or exclusive should/can technology education be defined? How should we deal with curricular diversity in pre-service teacher and graduate education? Has technology education come to be what industrial education is — a rubric for diverse forms of education? Witness the obstacles of interpretation that educators within the state of Maryland have had to traverse with their high school technology education requirement.

A subtle point to Figure 1 is: Regardless of technology education, students are, and have been receiving a Technology education. What is the nature of Technology education? How influential is ubiquitous Technology education? Is it time to look at Technology education in a broad light, across a spectrum of diverse programs and ubiquities?

Problems with diversity in technology education run deeper than what had been made evident through Wright's challenge. Generally blind to diversity in school settings, conceptions of teachers “in the trenches” have dichotomized this group into “laggards” versus “exemplary programmers.”

And, professional direction has too often been shaped through unrepresentative, closed-door, “white paper” work of “leaders.” Had diversity been considered, “the conceptual framework for technology education... [to be] disseminate[d]... to the profession” (Savage & Sterry, 1990a, p. 6) would have been representative and shaped through open discourse. Instead of an emergence of what is arguably a conservative “mission for technology education” (Savage & Sterry, 1990b, p. 7), a progressive mission may have been recovered. Instead of a static article of dissemination from “the group of 25” leaders “to the profession” (Savage & Sterry, 1990a, p. 6), “the conceptual framework” would have been an issue of deliberation for, and come *from*, the profession. With any glory that closed-door leadership offers necessarily comes the possibilities of having chosen the wrong style to lead or having led in the wrong direction. And, given Volk's (in press) analysis and other vital signs, there seems a heavy burden for a small group of leaders to want to bear.

Hopefully, the “Mill” style of defining professional direction has run its course. The time may be right for a new generation of planning in technology education; indeed, a democratic style that embraces values of diversity and discourse. Perhaps a *representative* conceptual framework would reflect a nexus of evolving ideas that recognizes diverse forms of scholarship, and voices of groups who share in the envisioning of futures for this profession: public school teachers and students; district and state supervisors; undergraduate and graduate students, and; assistant, associate, full, and emeritus professors.

For the sake of vitality in technology education, curriculum organization and professional direction ought to be viewed as problematic and contested terrain; and, kept epistemically open to discourse and debate (Petrina, 1992b). Voices ought to be heard and faces of diversity recognized and embraced. The fact that possibilities are open for curricular forms which fly in the face of disciplinary doctrine may be what makes this profession exciting.

Discourse on these concerns can be channeled through this journal, or through a public space at conferences dedicated to debate and expressions of “productive uncertainty.” Surely, gratitude must be extended toward the editors of JTE for inviting critical debate; still, Sanders retrospectively wrote in 1991 (p. 3), “the JTE lacks some of the 'dialogue' I thought it might foster.”

Rather than all applying “the same logic as science,” a challenge for technology educators may be to work on uniting diversities through discourse and reviving an historically grounded philosophy and sociological mission. In the meantime, we can *all* concentrate on examining our own curricular choices and securing a better education for our students than we would expect for ourselves. We can also concentrate on contributing more than our share to keeping the concept of Technology education a vital concern for this society.

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Tom Wright's Response to Petrina's Reaction

Thomas Wright

Reading Stephen Petrina's reaction to my recent JTE editorial was an interesting exercise. The numerous underlines he used and the misinterpretations he communicated caused me some concern. For example, I wondered how Petrina arrived at a statement that I "reluctantly" would accept bio-related and production as curriculum organizers. This statement reflects either a lack of careful reflection on what was written or a hidden agenda by the reactor. Two different systems were suggested for content organizers. Also, the term bio-related did not appear in the editorial and production appeared in an entirely different context.

However, the theme of the editorial was not on technology educator's favorite topic for academic discussion: *Which content organizers should we use?* The preoccupation with this topic has dissipated many people's energies from the real issue of the field: *How do we develop and deliver quality programs that people outside our profession will value?* To this end I suggested that diversity, as I interpret Petrina's understanding of the word, has not served us well for a number of years. Allowing each individual the freedom to define technology education in any way he or she chooses serves students and the profession poorly. However, the belief communicated by Petrina that curriculum freedom is a basic right of all teachers is not new. We've had this level of "diversity" for years. Michaels (1978), reflecting on industrial arts on the eve of his retirement, suggested that the field was eclectic. He indicated that the industrial arts teacher could "choose what appears to be best from diverse sources, systems, and styles" (p. 2). He then listed nine rationales that were in use for the field: historical-common heritage, workshop-learning by doing, skills-for-skills sake, industry-technology, creativity-problem solving-design, career awareness-occupational preparation, utilitarian-handyman, special needs learners. There's little wonder that even today industrial arts is hard to define and describe. It was anything that anyone wanted it to be and it was valued by few educators outside the field.

During the 1960's curriculum thought changed direction. There was basic philosophical agreement among curriculum reformers that the randomly focused, tools and material-based industrial arts was inappropriate and that in-

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dustry should be the new curriculum base. Within this context there were a number of approaches to teach about industry. This resulted in a common vision with alternate approaches and gave the field a spurt of growth and new recognition.

With the advent of a technology curriculum focus, the profession lost its industry-based vision and began to diversify. The technology camp led by Paul DeVore and the industry camp lead by Willis Ray and Donald Lux spent considerable time and energy advocating their positions. This discussion was good but the diversity caused the field to lose sight of its basic challenge: to alter industrial arts significantly to meet the needs of youth for the emergine information age. To address this problem the Jackson's Mill group concluded that if progress was to be made in changing industrial arts from woodworking, metalworking, and drafting, the change agents must compromise — sacrifice some of their diversity. This group agreed that (1) industry and technology and their impacts on society should be the focus of the emerging field, (2) the content of the field could be organized around the productive activities that humans have, are, and, most likely, will be engaged in, and (3) these activities are best understood by viewing them as systems.

In both of these instances cited above, there were change agents who had a vision for the field and there was a central mission agreed upon by many practitioners. The editorial that Petrina finds fault with suggests that this is a time when technology education needs a common vision. It is not one in which free-wheeling diversity will serve us well. Those who suggest otherwise may need a dose of reality. Public school and teacher education technology education/industrial arts programs are closing in nearly every state. The spate of curriculum reform documents of the 1980's almost totally ignored our profession as contributing to the general education of youth. Only Boyer's *High School* suggested a seminar on technology — not hands on/minds on technology education. This condition can be explained, in large part, because there is not a clear vision of the mission, goals, content, and practices of technology education that can be articulated to those outside our field.

We are in a crisis of credibility brought on by failing to reach a compromise on what is the central vision for the field and the essential contributions (content and processes) it can make to the youth of America. This crisis can be terminal if we continue to debate lofty issues among ourselves and fail to deal with the problems at hand: developing a credible product that other people value. This cry for action is not designed to “render voiceless” alternate curriculum models as Petrina suggests DeVore and I would do. However, it is to suggest that without some common vision of what is important, the field is left with little to “sell” to the general public. We may believe we are vital in the education scheme; but how many people outside technology education share our convictions? We live in a hostile educational environment of increased demands on student time, reduced electives, tight budgets, and a back-to-the-basics movement. Trying to be all things to all people under the rubric of diversity may let us be nothing to nobody.

Before we all rally under the flag of diversity-for-diversity sake, we need to list the advocates for technology education who are outside our field. If they are few, which I believe they are, then we need to decide how we develop allies. I believe the approach is fairly simple and I tried to explain it in my editorial. Simply put we must (a word Petrina reacts strongly to) decide what we are and what we are not. Then we must develop programs that can be clearly articulated. These programs cannot be solely based on an individual teacher's abilities, interests, and expertise. And finally, as I suggested in the editorial: we must resist the *product consumption mentality* presently being used by some change agents. We need not discard our curriculum structures and philosophical foundations with the same frequency as we do automobiles and clothing.

As much as Peterna dislikes the words “must,” “all,” and “challenge,” I suggest that unless we are ALL in the fight together we will fail to meet the challenge. Another generation of young Americans will graduate technologically illiterate and technology education may well disappear from public schools.

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Book Review

Beynon, J. & Mackay, H. (Eds.). (1992). ***Technological literacy and the Curriculum.*** **The Falmer Press, $29.00 (paperback), 207 pp. (ISBN 1-85000-986-4)**

Reviewed by Mark Snyder

The reviewed book consists of a collection of essays purported to contribute to the so-called debate over the content and meaning of the phrase "technological literacy." In the preface, the editors, from the Polytechnic of Wales, defined their perspective of the topic as follows: "Our view of technological literacy is very different from a narrow, skills-based, technical perspective. We see the cultural and social as central to the technology curriculum, not marginal" (p. vi). Indeed, the editors (and most of the contributors to this reading) are academicians in the realm of the social sciences. Clearly, the intent of the publication is to broaden the accepted definition of technological literacy and to alter the consideration of technology in education to that which includes primarily a cultural-orientation. Second in a series of three books published by The Falmer Press, which is based in England, *Technological Literacy and the Curriculum* was preceded by the book *Understanding Technology in Education*. This initial volume may perhaps serve as the first indicator that the editors themselves are not fully aware of the aims of technology education or, given the benefit of the doubt, that they would prefer it be something other than is. As a result, the content of each book is focused primarily upon the separate topic of educational technology rather than technology education. In fact, the majority of the essays included within are specifically concerned with computer literacy. The following statement by Beynon, from *Technological Literacy and the Curriculum*, clearly indicates the filter through which he has drawn his perception of technological literacy:

> We have made it clear that I dislike the term computer literacy and prefer the more generic term technological literacy. Why? Quite simply I would prefer that computers were not decontextualized and studied separately but as part of a

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> wider culture of technology that includes, for example, television, cable and satellite, teletext and viewdata, and telephones. (p. 23)

Indeed this book does much to cloud, rather than contribute to, the so-called debate over the use of the phrase “technological literacy.” Mackay did include some very thoughtful questions related to technological understanding in his article “From Computer Literacy to Technology Literacy” and identified some potentially beneficial aspects of the National Curriculum Technology. However, he continually limited his discussion to computer-based technology and implied, in his final statement, that the National Curriculum Technology is not educationally sound. Perhaps this is due to the editors' opinion that “education is too important to be left to technologists” — a quote from an article by Beynon and Mackay titled “Information Technology into Education: Towards a Critical Perspective” printed in the 1989, volume 4, number 1, issue of the *Journal of Education Policy*. Still, there are at least two more articles contained within this book that are worthy of further consideration by Technology Education professionals for their discussions of the Technology portion of the recently mandated National Curriculum of England and Wales. Peter Medway's investigation of how and why technology was included in the National Curriculum is extremely severe. His article, “Constructions of Technology: Reflections on a New Subject” consists of a number of possible scenarios, based on speculation, as to what were the aims of the developers of the technology curriculum. Perhaps Mr. Medway could have simply spent more time trying to gain the perspective of the developers firsthand. Nevertheless, herein lies an open declaration against the consideration of technology as a discipline. Medway, a former English and Humanities teacher who led the national evaluation of technology education, wrote:

> Not only is the technology curriculum based on a “discipline” which has no real existence as an integrated entity outside the aspirations of the curriculum designers; it is also a highly selective construction in which ideology plays a conspicuous part. (p. 76)

That the technology curriculum is being described as a discipline rather than simply a rehabilitation of “the practical” seems to be Medway's greatest concern. Medway concluded that the new technology curriculum is in fact “at odds” with the other required curriculum areas. He perceived it as an attempt to “address the entire principle of the practical in one subject” (p. 80). Michael Barnett, another contributor to this book, agreed that the new approach might cause merely a modest improvement of “the old craft subjects” (p. 96). Barnett's “Technology, Within the National Curriculum and Elsewhere” was decidedly aimed at proving that the National Curriculum Technology was not thoughtfully linked with the technology of the “real world” — going so far as to call it “mickey mouse.” Drawing attention to the fact that most of the activities in the technology curriculum are relatively “low tech” he declared that they do little more than “scratch at the surface” of current key technologies such as biological materials, semiconductors, ceramics, ion beam implantation, optoelectric devices, mechatronics, sensors, image processing, flexible manufacturing, etc. In Barnett's opinion, then, the National Curriculum Technology should only be considered “a circumscribed intervention in the field of general education” (p. 96).

Barnett also expressed the concern that societal issues and the wider implications of technology cannot be addressed except through a cross-curricular approach, and that the present technology curriculum falls well short of being interdisciplinary in nature. Not to fault the developers, Barnett recognizes that this is largely due to the nature of “the lumbering circus-train of the National Curriculum” (p.100). In the past few years, there have been many comparisons and contrasts of the American and English approaches to teaching technology. Many aspects of the English system of teaching technology have been considered superior to the American system. As part of a National Curriculum, however, it has been presented quite differently in England and Wales than in the technology education curricula in the United States. Perhaps, because it was a mandate, it has caused conflicts with other agendas and has invited the opposition to technology education that is evident in this publication. More likely, however, it is the result of misunderstanding the aims of technology education and/or a reluctance to accept a new paradigm. Regardless of that which compelled it, this biting commentary is valuable to technology educators worldwide as it is one of the first extremely critical reviews of technology-based curricula.

Miscellany

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