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Miscellany

From the Editor

In Praise of Technology Education Content and Method

It is gratifying to be a part of a field that has more relevant and exemplary *content* and *method* than perhaps any other subject area in our schools. This secret has been remarkably well-kept from the public, and to some extent, other educators as well. The problem is, not even those of us in the field have come to accept how important our content has become or how well suited our methods of instruction are to educational institutions in the midst of reform.

Consider first the *content* of technology education. We teach about technology, as we always have. But now, it seems all school subjects are also teaching about technology. Science is the most visible in this respect, but mathematics, language arts, and social studies have taken up the task as well. While the science education community is currently wrestling with how best to teach the relationships between technology and science (see, for example, National Research Council, 1992), progressive science teachers are "just doing it." Toshiba thinks enough of the science/technology connection to have provided $1 million for the new "NSTA/Exploravision" contest. Though promoted last year only to science teachers/students, it is unquestionably a technology contest, and every technology teacher reading this should contact the National Science Teacher's Association to get on the mailing list for next year's contest guidelines. Bob Daiber has shown our profession that we *can* compete successfully in this regard, having had two of his students finish first and second the last two years in the NSTA/Duracell Contest. And, as if $1 million weren't enough for this sort of thing, Nynex and Sprint are also looking to sponsor similar contests. Whatever the new "science standards" currently being developed end up looking like, you can be sure they will address the role of technology in the science curriculum. The math standards have already done so (National Council of Teachers of Mathematics, 1989).

But science teachers teaching about technology is not all that new. Many progressive science teachers have long incorporated the content of technology in their courses. Science Fairs have served as showcases for this phenomenon and the Science-Technology-Society movement has been pushing the idea for more than two decades.

More surprising is *Technology: Inquiry and Investigation* (Doyle, 1992) a beautiful little text that does a nice job of presenting the technological world to the middle school student. When I first saw this glitzy, four-color publication, I thought one of our publishers had released a new gem. Its title led me to believe it was developed for the middle school course "Inventions and Innovations" being taught here in Virginia and elsewhere under similar names. But that is not the case; it is a *language arts* text. Apparently, at least one publisher has discovered what we have known for a century – technology is inherently interesting to many people, and thus it makes sense to use its subject matter as a *medium* to teach other content. This is a theory we have toyed with throughout this century, but never bothered to test empirically. Our literature and research is painfully vacuous in this regard. Nevertheless, other disciplines are playing out that scenario. Incidentally, this language arts text provides a definition of technology that recognizes our content organizers: "Practical or scientific knowledge used to create, build, or move things, to generate energy, or to communicate."

I confess I am not well acquainted with current social studies texts, but I would be willing to wager that they too focus increasingly on technology. After all, the relationship between technology and culture led the Smithsonian Institution to rename what used to be "The National Museum of History and Technology" to "The National Museum of American History." Not surprisingly, its exhibits continue to show a decided emphasis on technology.

The relevance of our content is complemented by our *method*. As educational policy makers struggle to revitalize our schools, they would be well advised to look closely at the methods routinely employed by technology education. Here is where we have always sold ourselves short, for the methods we use are optimally suited to the learning theories currently influencing educational reform. This is particularly true as we increasingly adopt a "technological problem-solving" method in our field.

Proponents of constructivism seek a learning environment in which students can actively build their understanding of the world. I can think of none better than a good technology education laboratory. Not the new, no-think modular variety, but the more traditional general laboratory that facilitates hands-on technological problem-solving. Educational policy makers believe they are standing the world on its ear with "outcomes based education," yet we've always built our curriculum with outcomes in mind. New approaches to the teaching/learning process have led to a frantic search for "alternative assessment strategies." On this behalf, "portfolios" are being touted as a new means of assessment, yet we've required this sort of documentation in our courses for a century.

"Hands-on" activities that address "real word problems" are all the rage, particularly in science and mathematics. We literally wrote the book on this one.

We employ hands-on problem-solving activities for roughly three-quarters of the instructional time in our courses. Moreover, we typically manage a wide range of different hands-on problem-solving activities concurrently in our labs. I do not think we have come to realize how adept and unique we are in this regard. “Hands-on” activity for a science teacher, for example, generally means all students doing the same thing at the same time to observe the same scientific theory or principle. This is analogous to the “Russian System” which we embraced in the late 19th century and have long since abandoned. Can we picture a mathematics teacher challenging some students to solve real-world problems with algebra while some do so with geometry, others with trigonometry and so forth? It just doesn’t happen.

Interdisciplinary instruction, the underlying premise of the middle school movement, presents another opportunity for technology education content and method. I can think of no better place in the schools to demonstrate the relationships among technology, science, mathematics, language arts, and social studies than in a good technology education facility using problem-solving activities. This approach is beginning to occur in some of the most progressive middle schools.

There is a growing number of technology education programs that are embracing “technological problem solving” as a means of engaging students in the study of technology. Admittedly, there are others that have not yet made the transition. But those that have are setting an example for all of education. It is downright gratifying, even if it *is* a well-kept secret.

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Articles

A Study of Three Approaches for Teaching Technical Content to Pre-service Technology Education Teachers

Dan Brown[1]

Policy and decision makers within technology teacher education are searching for means to revitalize weak programs, meet the needs of their clients, and adapt in ways that will help insure the continuation of their programs. Insight into the effects of different approaches to providing technical content in technology teacher education programs may aid in this quest. Based upon discussions with technology teacher educators, it is apparent that in this time of change within the technology teacher education field, there is a need for greater insight into the effects of organizational configurations and approaches to technology teacher education.

The purpose of this study was to explore faculty and administrator perceptions of the interaction between technology teacher education and industry-oriented technology programs. This study was designed to explore the outcomes which faculty attributed to organizational configuration and to further explore relationships faculty perceived between the source of technical instruction and effectiveness of technology teacher education programs. Specifically, this study sought answers to the following question: As a result of the organizational structure and technical course configuration adopted by their department, what interaction do faculty, and administrators perceive?

Background

Many organizational configurations exist for technology teacher education programs but most programs coexist in contexts alongside one or more industry oriented technology programs (Savage & Streichler, 1985; Streichler, 1988). Further, most technology teacher education programs provide some or all of the technical content for their students through enrollment of teacher education

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students in technical courses designed for industry oriented technology majors (Andre, Chin, Gramberg, Skelly, and Wittich, 1990).

Historically, both industrial technology and technology education programs evolved from common roots (Rudisill, 1987; Streichler, 1988; Depew, 1991). In most cases industry oriented technology programs were developed in response to the observation that many students who obtained college degrees from industrial teacher education programs went directly into industry. Subsequently, many programs determined that if the time devoted to the education component of these programs were instead focused on content more appropriate to the needs of industry oriented students, it would enhance the preparation of those students. At that time, the technical course content of both types of programs was very tool skill-oriented and the same technical courses were often considered satisfactory for both groups of students.

Andre et al (1990), in a survey of 45 teacher education programs, identified three arrangements that exist for providing technical courses to technology teacher education students:

1. Programs that require technology teacher education students to take separate technical courses.
2. Programs that require technology teacher education students and industry oriented technology students to take some of the same technical courses and additional technical courses unique to their professional aspirations.
3. Programs that require technology teacher education students and industry oriented technology students to take the same technical courses.

Ritz (1991) described the content of traditional industrial arts programs as the "development of knowledge and skills of the processes used by industry" (p. 4). In the mid 1980s the industrial education field began to shift away from its traditional focus on the study of skills and processes used in industry. The industrial arts segment of the industrial teacher eduction field began a series of name changes starting at the national level that reflected a major top down shift in the philosophy and direction of the field. This movement was away from traditional industrial arts and toward technology education as a means of providing students the opportunity to develop technological literacy.

> (T)he mission of technology education is to prepare individuals to comprehend and contribute to a technologically-based society (Savage & Sterry, 1990, p. 20).

Thus, the new goal was not to develop skills, but to increase understanding of the concepts of technology and its impacts on individuals and society. As this shift occurred, a parallel shift developed within traditional industry oriented technology programs as they began focusing more sharply on the goal of preparing “management-oriented technical professionals” for industry (Rudisill, 1987).

As the shift in philosophy and direction slowly progressed through the field, concerns with the compatibility of technology teacher education and its close sibling, industry oriented technology programs, began to emerge in print. Rudisill (1987) described the current environment in the field as one of “conflict and chaos.” A number of areas which could be impacted by the technology teacher education program's position in a multipurpose academic unit or as a result of the sharing of technical courses with industry oriented technology programs were suggested (Rudisill, 1987; Depew, 1991; & Streichler, 1988).

Philosophical differences reflected in the curriculum

The missions of technology teacher education and industry oriented technology programs are fundamentally different. Teacher education programs focus on preparing individuals for careers in public education, whereas the primary mission of industry oriented technology programs is to prepare technically competent individuals who will be working in business and industry, primarily in management positions (Depew, 1991; & Rudisill, 1987). “The technical content (in the industrial technology program), in many instances, may be far too sophisticated and devoid of practical hands-on experiences considered essential for the teacher education major” (Depew, 1991, p. 58).

Faculty development needs

“Very often faculty members with backgrounds in industrial arts or industrial-vocational education do not have adequate mathematics and science backgrounds and individuals with engineering backgrounds do not have adequate preparation in the setup and operation of laboratory courses” (Rudisill, 1987, p. 16).

Faculty relationships

There are often deep feelings of conflict and hostility apparent between some faculty from industrial arts/technology teacher education programs and industry oriented technology programs (Rudisill, 1987).

Nature of the leadership within the programs

Streichler (1988) noted that most of the department heads responding to his survey “had strong roots and loyalties to teacher education” (p. 5).

Influences of institutional goals

“In an institutional environment that places great value on enrollment growth, the tendency in most academic units is to promote the programs with greatest potential for meeting enrollment goals” (Depew, 1991, p. 58). Similarly, enrollment trends may make it easier to justify hiring faculty in programs with significant growth patterns than for programs with histories of shrinking enrollments such as industrial arts/technology education (Depew, 1991).

Demands of accrediting agencies

"The program guidelines for NCATE (National Council for Accreditation of Teacher Education) are broad and require that each program apply the guidelines concurrently with state certification requirements. The guidelines for NAIT (the accreditation agency for industrial technology programs) accreditation are program specific and are applied to all programs equally regardless of state teacher certification requirements" (Depew, 1991, p. 58). Demands from accrediting agencies for very specific faculty credentials make the hiring of faculty that can meet the demands of both teacher education programs and industry oriented technology programs not practical or possible (Depew, 1991).

Mathematics and science requirements

Rudisill (1987) states that "Industrial arts/technology teacher education standards require little or no background in mathematics and science while industrial technology standards require a significant number of credit hours in mathematics and science course work and in the application of these principles in technical course work" (p. 13).

Impacts on recruitment and retention

Streichler (1988), from a survey of 11 multi-purpose units across the nation, identified a dramatic shift in enrollment toward the industry oriented programs. Between 1976 and 1986, industrial teacher education enrollments fell from 1070 students to 304 students while enrollments in industry oriented programs rose from 2397 to 4588. Depew (1991) points out that upon graduation from industrial technology programs, the best potential students can make substantially higher salaries in industry than if they opt to teach technology in the public schools.

Service to identified clientele and future directions of the program

Streichler (1988) also mentioned these as possible areas of interaction but not discuss them further.

Methodology

Yin (1989) described a case study as an empirical inquiry which investigates a phenomenon (utilizing multiple sources of evidence) within its real-life context when the boundaries between the phenomenon and context are not clearly evident. Technology teacher education is an example of a real-life context where boundaries are not always clearly identifiable. Pre-service technology teacher education students may be enrolled in technical courses designed for industrial technology students, engineering technology students are sometimes enrolled in classes designed for pre-service technology teacher education students. Faculty and facilities may be shared by technology teacher education programs and industry oriented technical programs. Case study techniques provided the means to develop insight into similarities and differences in this complex context.

Description of Programs

Program 1. Eight faculty members and one administrator participated in the study at this site. The mean reported age of faculty members was 41. The mean number of years in teaching reported by faculty members was 16.25, with two reporting one year, and three reporting from 25 to 31 years each. All of those individuals reporting were members of ITEA and 75% reported membership in CTTE. No more than 25% reported membership in any other single professional organization.

This program was housed in a department that also housed industrial technology and engineering technology programs. The technology education pre-service teachers and industry oriented students were required to take separate technical courses. Over the past five years, 190 students, for an average of 38 students per year, graduated with Bachelors or Masters degrees in education. The average number of Bachelors degree graduates in the industry oriented programs over the same five year period was 67.8 per year for a total of 339.

This program was housed in a two-story, 30 year old building that had been well maintained. It shared this facility with several other technical programs. The building layout was very traditional, with many faculty offices located adjacent to laboratories. Laboratory equipment was a mixture of modern table-top training equipment, traditional industrial arts type tools and industrial grade equipment. Some laboratory facilities were shared with faculty members from the industry oriented program.

Program 2. Only faculty members that routinely taught technology teacher education students technical or pedagogical courses were interviewed. Eight interviews were granted: four engineering technology faculty, three teacher education faculty and one administrator. The mean age reported for teacher educators was 49, and the mean age of the industry oriented technology faculty members was 45. The mean number of years in teaching reported by the teacher education faculty members was 25.3 years, while technology faculty members reported an average of 12.5 years. All teacher education faculty reported membership in AVA, ITEA and CTTE. Three of the industry oriented technical faculty reported membership in SME and AVA, 2 reported membership in NAIT and ITEA.

This program was housed in a department that also housed engineering technology and general technology programs. The technology education pre-service students and industry oriented technical students were required to take some of the same technical courses (a common core), and additional technical courses unique to their professional aspirations. Over the past five years, 57 students, for an average of 11.4 students per year, graduated with Bachelors or Masters degrees in education. Over the same 5 year period, 145 students, for an average of 29 students per year graduated with Bachelors degrees the industry oriented programs.

This program was housed in two adjacent one-story buildings, one of which had a basement that contained additional offices and a machine tools laboratory. The newer building was 40 years old and the older one was 70 years old. Both buildings had undergone recent renovation and modernization. Laboratory equipment was a mixture of new and old, but the emphasis was still on traditional industrial arts type equipment. Computers existed in some laboratories, particularly the drafting laboratory, but traditional hand tools, engine lathes and wood working equipment were still prominent in many of the laboratories.

Program 3. Only faculty members that routinely taught technology teacher education students technical or pedagogical courses were interviewed. Eleven interviews were granted: five industrial education program faculty members, five industry-oriented program technical faculty members and one administrator. The mean reported age for teacher educators was 53, and mean age of the technical faculty members was 50. The mean number of years in teaching reported for teacher education faculty members was 26.75, while the average for technology faculty members was 12.8 years. All teacher education faculty members reported membership in ITEA and CTTE, with three also reporting memberships in AVA. All of the technical faculty reported membership in NAIT and one was a member of ITEA.

This program was housed in a department with business education. Technology education pre-service teachers were required to take all of their technical courses from programs within the Industrial Technology and/or Interdisciplinary Technology departments. Over the past 5 years, 139 students, for an average of 27.8 students per year, graduated with Bachelors or Masters degrees in education. One thousand one hundred fifty five students, for an average of 231 students per year, graduated with Bachelors degrees from the industry oriented programs.

Housed in one corner of a 20 year old building that was dominated by the industry oriented technology departments, only laboratory space for teaching woodworking and elementary technology education was allocated for use with this program. There was an effort underway to procure funding to renovate the traditional woodworking classroom. While they had no technical laboratories of their own, the industry oriented programs which provided the technical courses had modern, well equipped laboratories, many of which had recently been upgraded and contained tools and equipment typical of those seen in modern industry.

All three of these programs were located at State Universities that had strong elementary and secondary teacher preparation traditions. All three programs also had long standing industrial education teacher preparation traditions.

Procedure

This was an exploratory case study. It included three cases, one from each of three approaches for providing technical courses to technology teacher education students.

Data collection. Twenty eight open-ended interviews, using a general interview guide approach (Patton, 1990), were conducted. The interviews ranged in length from 45 minutes to 2 hours with most lasting about one hour. To supplement each interview, the faculty members were asked to complete a questionnaire containing demographic information, historical information, and questions regarding curriculum, instructional methods and materials. Twenty three questionnaires were completed and returned. Related documents such as program catalogs, course descriptions, and graduation requirements were also obtained and analyzed.

Data analysis. The interviews were tape recorded, literally transcribed and coded by looking for patterns and recurring themes which were subsequently filtered through the focus of the research questions. Careful analysis and comparison of each interview against other collected data provided insight into the respondent's perceptions of the effects of the technical course configurations at each site.

Results

This study strategy was inductive. It was an attempt to make sense of the context without imposing preexisting expectations on the setting. It began with observations and conversations and built toward general patterns (Patton, 1980). By its nature it was exploratory. Not all the questions it raised were answered, but understanding was increased.

As a result of the organizational structure and technical course configuration adopted by their department, what interaction do faculty members, and administrators perceive with respect to the following factors?

Ability to support a common faculty philosophical position. The personnel at site 1, where all technical instruction was provided from within the program, talked more about philosophical issues than program survival. The consensus at this program was that the configuration they have adopted makes adherence to their philosophical position possible. The discussion at site 2, where a common core of courses for both technology teacher education students and engineering technology students was utilized, was much more pragmatic. Here there was little discussion about philosophical position. Philosophical position seemed to take second place to the more practical issue of maintaining enrollments at course level.

The most diverse philosophical positions were held by faculty members at site 3, where all technical courses were provided by other departments. Faculty here expressed concern that the approach currently utilized at this site may not adequately support their philosophical position; however, there was not total agreement on what their collective philosophical position should be. The technology teacher education faculty at this site had been engaged in negotiations on the future philosophical directions of the program. It appeared that the configuration they planned to adopt would be eclectic. In the future, the technology teacher education faculty hope to begin teaching additional technical courses while some technical courses would continue to be provided by other departments.

Faculty relationships. Faculty relations between the industry oriented technical faculties and the teacher preparation faculties, both where all technical courses were provided from within the technology teacher education program and where all technical courses were designed for students from other non-teaching programs, were strained. Individual relationships occasionally ran counter to group relations. Where technical courses were not utilized from within industry oriented programs, faculty indicated that their teacher education faculty, subsequent to adoption of their present configuration, came together more as a team.

Nature of the leadership within the groups. site 2, where a common core of technical courses was utilized, displayed a unique organizational situation. The administrator and many of the engineering technology faculty members have teacher education backgrounds and orientation. The industry oriented programs, as at many schools, developed historically out of the teacher education program, but here the industry oriented programs have not acquired control of the department. It appears that the department is instead dominated and controlled by and for the benefit of the teacher education program. Some faculty members speculated that as the engineering technology faculty pursues accreditation (which it was exploring), the balance will probably shift away from having faculty with teacher education backgrounds in the technical programs and toward employment of engineers and other industry oriented technical persons as instructors.

Influences of institutional goals. Because the self-contained configuration, like that at site 1, requires laboratories, it is very resource dependant, thus the level of institutional support is a critical factor in the configuration selection process. Faculty members at site 1 observed that, if adequately supported, the configuration that requires technology teacher education students to take technical courses taught by faculty members within their own program demands a larger faculty and offers the chance to be more politically viable.

At site 3, where all technical courses were provided through other programs, a different situation was described. Here administrators beyond the program level appeared to value accreditation while the technology teacher education faculty members appeared to be pursuing a reorganization plan that was described as “not consistent with current NCATE accreditation guidelines.” These faculty members were trying to redesign their technology teacher education program, while continuing to live with the political after-effects of their history (utilizing technical courses from industrial technology and interdisciplinary technology programs that have different focus and mission).

Effects of the demands of accrediting agencies. Because the approach at site 1, which provides all its own technical instruction, allows total control of technical course content for technology teacher education students, faculty members believed it was more easily adapted to the challenge of meeting NCATE guidelines. The faculty at this location believed that their configuration contributed to their successful efforts to obtain accreditation.

Mathematics and science requirements. Table 1 illustrates mathematics, science, and computer science requirements for each site. These requirements were diverse.

Some members of the faculty at all three sites believed that mathematics and science requirements should be higher. Often, however, when discussion turned to the need to raise mathematics and science standards, the over-riding consideration was not whether students need to study higher levels of mathematics and science, but rather, what the impact of higher mathematics and science requirements might have on future enrollments. Some faculty members stated that, traditionally, the student pool that provided students for industrial arts teacher education contained many students who were not adept in mathematics, science, and many other academic subjects. The students with math and science abilities traditionally majored in engineering, science or other higher paying fields.

Impacts on recruitment and retention. Teaching all their own technical courses forces the faculty members at site 1 to recruit students because they can not rely on students from other programs to fill their courses. The ability to depend on engineering technology students enrolled in common core technical courses, conversely, may encourage faculty members at site 2 to become complacent about recruitment, as they can rely on majors from other programs to keep these courses full. Faculty members at site 3 occasionally noted the need for more students in their program but did not discuss recruitment efforts or plans.

Ability to serve the identified clientele. Forced to provide all technical instruction to students in the technology teacher education program, certain site 1 faculty members worried that the technology teacher education faculty may not have sufficient technical expertise to adequately teach certain technical courses. This was not a universal perception, but some individuals clearly were unsure. The balance of this faculty believed the risks of sharing technical courses more than offset any problems the present configuration may produce.

At site 2, members of the technical faculty expressed fear that the content and level of instruction in some common core technical courses may not be ideal for preparing either public school teachers or engineering technology students. This concern was partially grounded in the observed tendency of teacher education students to model their own classrooms and teaching techniques after the classrooms they experienced successfully as pre-service teachers. There was also consternation among some engineering technology faculty that some of the courses were “common core” primarily to maintain enrollments for the teacher education program and were not always the best use of the engineering technology student's resources. The teacher education faculty generally accepted the present configuration as necessary for survival of their program.

While not in the majority, some members of the technical faculty at site 3 believed their present approach, that of providing technical instruction for technology teacher education students through courses designed for industry oriented technology students, assured that the teacher education students received more in-depth technical skills and knowledge. The assumption was that technology teachers needed “industrial strength” competencies.

Future directions of the program. Most of the teacher education faculty members at site 3 viewed their lack of control over the content of technical courses with consternation. They talked at length about the problems with utilizing technical courses from other departments. Additionally, they acknowledged that many of their students are community college transfer students that come to their program with their technical courses already completed.

The concern with utilizing technical courses from other departments or colleges may have been partially related to the perceived need to teach more courses within the program as a means of making the future of the program more secure. This was consistent with comments made at site 3 about the long history of providing large numbers of service courses for elementary education through the technology teacher education program. Apparently the future of those service courses was uncertain. If those courses were lost and the faculty were unable to find replacement audiences, they may not generate sufficient instructional units for the program to remain viable in its present size and form.

Table 1

Comparison of minimum mathematics, science, and computer science requirements across programs

Discipline	Program 1	Program 2	Program 3

	Graduation Requirements	Graduation Requirements	Graduation Requirements
Mathematics	Intermediate Algebra	3-5 hrs. College Math, or any other math and/ or computer science course(s)	Pre-calculus, or Calculus, or Math Analysis for Social Science 1
Science	Physics (1 course, Energy and Space Sciences)	4 hr. Biological science & 4 hr. Physical science (can include Astronomy or Geology	Fundamentals of chemistry & Fundamentals of Mechanics, Heat & Sound
Computer Science	computer competency to be acquired through technical course content	can be substituted for a mathematics course	1 course of Computer Science

At site 1, where technical instruction was provided from within the program, teacher education faculty continued to meet, discussing philosophical questions and generating strategic plans. They were attempting to develop an expanded recruitment plan. There was an emphasis on national leadership, publication and grant writing, activities valued by most universities regardless of the departmental configuration. Their configuration provided the opportunity for larger numbers of faculty members and more laboratories which may help make their future more secure.

The prevailing attitude at site 2, where common core technical courses were utilized, was that the future of the program would essentially mirror the status quo. Facility improvements and course changes were in process, but the changes appeared evolutionary in nature. There was some talk about the need to recruit, however, it was apparent that there was but limited enthusiasm for personal involvement.

The future program direction at site 3 was even less certain. A struggle to overcome its history and agree on a new philosophical position while faced with budgetary shortages was underway. Once established, organizational configurations seemed to take on a life and direction of their own that was often hard to change.

Conclusions

History

Themes in the history of how the programs developed as related by faculty members often seemed to provide a general set of advanced organizers categorizing more recent events. Conflict and cooperation at the faculty person level and interaction at the program level were those common themes. Faculty recollections of the history and factors that preceded the current organizational configurations and technical course delivery systems provided insights into how each program came to its present form. Philosophy of program leadership, student enrollment patterns, available faculty numbers, areas of faculty interest and expertise, available facilities and organizational politics both within and beyond the program itself, shaped the evolution of these programs. For the most part, the same environmental factors were present in varying degrees at all three sites as key decisions were being made. The subsequent differences appeared to depend on how faculty members in each program elected to react to their perceived environment.

Conflict and cooperation at the faculty person level. One technology teacher education faculty member (who was active at both the state and national level in technology education) stated that technology education has a commonly agreed upon definition, and therefore the goals of all technology teacher education programs should be common. Interviews at the three sites did not support this supposition. In spite of the fact that ITEA leadership has carefully defined technology education, no single operationally defined content for either technology education or technology teacher education has been universally accepted by technology education teachers and/or technology teacher educators. Philosophical differences appeared to exist at each of these three sites.

Recognizing these philosophical differences, no single best approach to providing technical courses or to organizational configuration for technology teacher education programs was identified. It appears that careful identification of the philosophy and basic assumptions behind a program are necessary steps in this very important planning process. The stated mission of the program and its clearly defined goals, when combined with the political and economic realities at that institution, should dictate the most effective configuration for any specific technology teacher education program. The approach utilized in any technology teacher education program should be carefully planned, based on the philosophical assumptions and goals of the faculty. In practice, it appeared that at these three sites, economic realities, political alliances, and the ideas or interests of a few faculty members with strong personalities and power bases may have often been more important than philosophy.

Interaction at the program level. Configuration type can apparently impact on faculty relations and cooperation, but is not the only source of either positive or negative relations. Where teacher educators conducted all their own technical courses, increased teamwork was apparent among the technology teacher education faculty. This same spirit of cooperation unfortunately did not extend to the industry oriented technical faculty. Faculty relations between teacher educators and industry oriented technical faculties were strained in both the program where all technical courses were taught by the technology teacher faculty and in the program where all technical courses were taught by faculty from other departments. This seemed to be a result of competition for resources and a historical split that falls roughly along “hard science,” “soft science” lines, or perhaps is reminiscent of the historical split between industrial arts (general education oriented) faculty and vocational education faculty.

When technology teacher education and industry oriented technology programs share technical courses, the needs of the program with the largest enrollments are likely to dictate technical course content and availability. Enrollments in the field have consistently shifted toward the industry oriented programs over the last 3 decades. The accreditation guidelines for technology teacher education, industrial technology and engineering technology are very different. This is predictable, considering different professional job requirements and uniquely different missions. Concerns related to accreditation at both site 2, with its common core of technical courses and newly designated engineering technology program, and site 3, with its historical dependance on other industry oriented technology programs for technical instruction, appeared to be exacerbated by the inflexibility inherent in the approaches adopted.

Industrial technology and engineering technology programs seem to be evolving in directions that include less hands-on activity and more math-based theory and management theory. The trend in their technical courses appears to be toward more specialization and depth. As this trend continues, technical courses designed for industry oriented students may become even less compatible with the goals and mission of technology teacher eduction. Before technology teacher education faculty members consider which, if any, industry oriented program technical courses to utilize for the preparation of technology education teachers, members of the faculty should reexamine their curricular goals and attempt to arrive at consensus about and the philosophy behind those goals.

There has long been an argument in technology education about whether the technical content should be focused on the functions of industry or broad aspects of technology. If the program goal is to focus on industry, the configuration that utilizes a common core of basic technical courses shared between the technology teacher education students and the industry oriented technology students may, if carefully structured, be advantageous because these courses could offer introductory content that is basic to both the processes found in industry and those explored in the secondary classroom. The configuration that utilizes only technical courses designed for industry oriented technology programs can provide sophistication and technical content depth and equipment that is compatible with certain segments of industry but may not be readily incorporated into the secondary technology education classroom. Conversely, if the goal is to focus on the broad aspects of technology, most technical courses designed for industry oriented technology students may be too narrow in focus. In this case the approach that provides all technical courses for technology teacher education students through instruction by technology teacher education faculty may be most appropriate because both its depth and breadth of technical content can be controlled by the technology teacher education faculty. This configuration can also provide the opportunity to focus the technical course content and laboratory equipment more directly on the needs of the teacher education student.

Recommendations

The effects of the approach to providing technical instruction can reach far beyond the technical competency attained by its students. Within the pool of larger organizations, policy decisions made by sub-groups, like rocks dropped in a pool, have effects that ripple throughout the larger organization impacting many other individuals and sub-groups. Program goals ultimately define the most effective organizational configuration. Inquiry should be conducted to find means to facilitate consensus building processes that lead to broad agreement on program mission and goals.

Further, studies should be conducted into the effects of organizational configuration upon enrollments, curriculum, facilities and faculty relationships within technology teacher education programs. Additional insight into the effects of providing technical instruction from outside teacher preparation programs might also be gained by studying teacher education programs outside our discipline.

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A Technological Teacher Education Program Planning Model

Ronald E. Hansen[1]

The purpose of the paper is to briefly state the case for a revised technological[1] teacher education program and describe a conceptual model developed at the Faculty of Education, The University of Western Ontario. The model outlined assumes that a re-thinking of how technological teachers learn to teach is necessary if new ways of teaching are to be fostered. The need has three dimensions. First, technology and the way we transmit knowledge about it in schools, is changing. Second, substantive analysis of past practices in technological teacher education are overdue. Third, teacher development is a complex human and professional process combining personal and environmental factors that are often poorly understood.

The curriculum design represented herein is a starting point for research, reflection and development only. A more comprehensive technological teacher education pedagogical model will evolve differently from one institution to another. There are two aspects to the design put forward for reader analysis: the elements which give the design its structure; and the program activities themselves. The description of both is condensed. The paper gives the reader information about the features of the model and, to a lesser extent, information about how to use it. A more detailed description of the teacher development project which led to the adoption of the new model and detailed information on its use is available (Hansen, R., Froelich, M., Fleisser, C., and McClain, J., 1991).

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[1]In Ontario, "technological education" is a term the provincial government has chosen to define a long-standing but evolving subject area. The term encompasses all technological education programs from Kindergarten to high school honours graduation. These include: technology in education (grades K-6), in which the learning of technology is part of an integrated core program for all students; design processess in technology (grades 7-9), an integral element of a math, science, and technology core curriculum for all students; broad-based technologies (gradess 10-12), a program which provides students with an introduction to one or more of six technology areas; concentrated technologies (grades 10-12) which provide skills development for students with an interest in a specific technical field; and Ontario Academic Credits (O.A.C.) for students wishing intense technological skills and knowledge in preparation for post-secondary studies in engineering or science.

The case for a revised technological teacher education program is based on the recent "research on teacher education" literature (Carter, 1990; Feiman-Nemser, 1990; Zeichner and Gore, 1990). That literature suggests that prospective teachers come to the profession with preconceptions of what teaching is all about. Technological education teachers, as observed in the project at the University of Western Ontario, are no exception. Compounding the problem is a growing alarm about teacher education program effectiveness. "Many people believe that teacher education is a weak intervention incapable of overcoming the powerful influence of teachers' own personal schooling or the impact of experience on the job" (Feiman-Nemser, p.229). Missing, according to Feiman-Nemser, from the research on teacher education, is a conceptual framework that identifies central tasks of teacher preparation, e.g. helping teachers to examine their preconceptions about teaching and learning; to learn about transforming subject-matter knowledge for purposes of teaching; and to develop a commitment to teaching all children.

The Technological Teacher Education Model

The challenge undertaken in this project was to understand these preconceptions and to transform the technological teacher education curriculum as it existed at The University of Western Ontario. Four aspirations guided the program reformulation process. First, the faculty members involved wanted students to achieve a sense of professional self-awareness. Schon (1987) refers to such awareness as "reflective practice." Being able to isolate preconceptions is one thing; intelligently and systematically modifying them is another. Understanding the curriculum development process, i.e. being able to separate "what to teach" from "how to teach" questions, was the second direction. Third, the ability to connect higher order learning outcomes (e.g. independent learning ethic, critical thinking) with meaningful classroom experiences was a priority. Finally, the issue of "context" for student teachers required attention. What is technological education? Why have technology in the curriculum? The introduction of the program was linked to a comprehensive research project and program evaluation.

To help the reader conceptualize the model that evolved, a series of illustrations follow. Figure 1, an axonometric note-pad representation, is based upon the systems elements of input, process, and output. The 'input' stage in the teacher preparation process is comparable to recruitment into the profession. Candidates in the UWO program are selected based on a set of criteria which includes technological expertise and knowledge, formal and informal education accomplishments related to technology, and a disposition for organizing and sharing knowledge and competencies with adolescents. Admission to the program is highly competitive (one out of ten applicants is admitted) and involves interviewing as well as competence testing. A teacher-needs analysis within the target region of southern Ontario is used to rationalize and justify the recruitment process from year to year.

The "process" stage, detailed on the conceptual model and the main thrust of this paper, has several components. The three views, front, top, and side, correspond to a program emphasis. Each emphasis is focused around a curriculum question; what should be learned? (content) how should it be learned? (process) and why should it be learned? (purpose). Together they give technological teacher educators and program planners a general framework from which to consider program development, both in consecutive and concurrent teacher education programs. The practice of "planning" and "conceptualizing," processes so integral to effective learning in technological education classrooms, is followed here to help the reader.

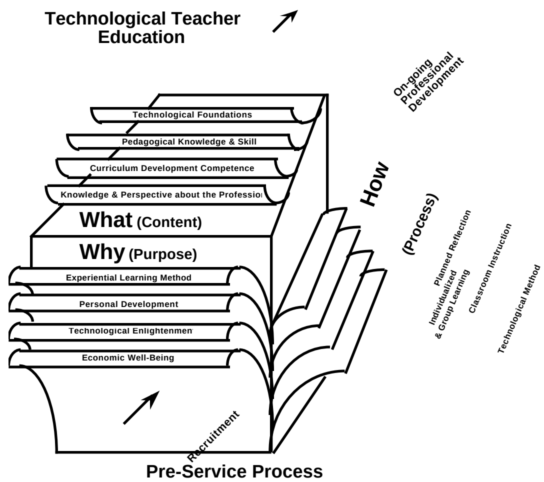

Figure 1.

The Curriculum Content

The curriculum "content" part of the program (Figure 2) includes four components: technological foundations, pedagogical knowledge and skill, curriculum development and knowledge of the profession. Technological foundations involves topics such as the history of technological education, the sociology of work, education and the economy, and ultimately the sociology of technological education. The need is to give would-be-teachers in technology education a context in technology and a grounding from which to better understand its many places in the school curriculum, and its relevance to social, economic, cultural, and political policy development. The program engages students and a range of faculty with social science backgrounds in a series of seminars. The concept of pedagogical knowledge and skill for teachers is defined by Shulman and Sykes (1986) as the core concepts, skills, and attitudes which a given topic has the potential of conveying to students. One example core concept in technological education that is often learned and reinforced is "economization/optimization." Each time a student is invited to develop a pattern for an object or artifact, a resourcefulness mind-set as well as skill is being acquired; examples include the development of a garment pattern or the design of a floor plan with different configurations for making maximum use of flooring materials.

To introduce curriculum development concepts and curriculum writing skills, three studios were conceived, one in each of: computer graphics, design studies, and communications technology. Each studio was created to be "process" rather than "content" orientated. Student teachers are invited to develop curriculum learning units with a problem or a challenge focus rather than a specific subject focus. Finally, knowledge of the profession involves a deliberate attempt to prepare aspiring teachers for their fifth year in the profession as well as their first. Topics include professional development theory, teacher wellness, conflict management, and leadership/followership values, to name a few.

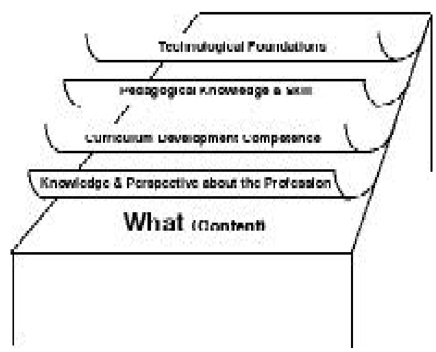

Figure 2.

The Curriculum Process

The curriculum "process" part of the program (Figure 3) includes planned reflection (examination of one's own preconceptions and how they change over time), classroom instructional strategies (the introduction of important topics in teacher preparation e.g. lesson planning, objective writing, peer learning, and student assessment), individualized and group learning (independent and small group inquiry skills were developed by the students through a learning package and student socialization opportunities), and an introduction to a technological method based on the work of Savage and Sterry (1990), for the transmission of knowledge and the development of new knowledge.

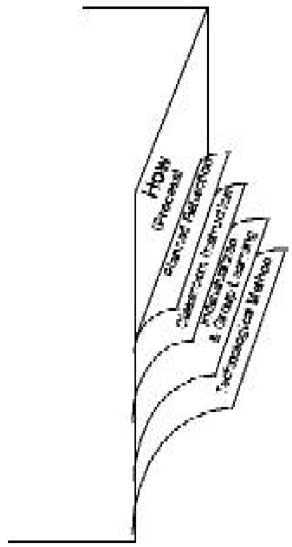

Figure 3.

The planned reflection exercise developed for students involves a conscious effort to monitor and experience at the same time, the “gap” or “dissonance” that students find between what they learn in their Faculty of Education classes and what they discover in the practicum. An observation and practice teaching assignment guides the learning exercise. Outcomes of the reflection are a better understanding of the “ideal” teacher, student, curriculum, and school milieu (Clandinin and Connelly, 1988).

Classroom instructional strategies are taught and experienced at the same time. A ten week practicum in local schools serves to give student teachers an opportunity to both practice conventional instructional formats and alternative pedagogical strategies. A significant part of the student teacher's development is to always consider dimensions of “learning how to learn” while facilitating the learning of core concepts. An independent self-paced learning package corresponds to and complements the traditional teaching methods material found in most teacher education programs. The exercise also reinforces the life-long learning ethic so important in a learning society.

The technological method (Savage and Sterry, 1990) provides the program with a vehicle for involving students in the teacher development problem solving process while it is happening. Using the problem solving steps, students are asked to identify their own perceived needs vis-a-vis becoming a successful teacher, and lay out a strategy to meet those needs. The aim of the focus on the technological method is to reinforce the knowledge technologists have about their own field but never articulate in other than an everyday problem solving discourse. It is quite a comfort for students to discover that the problem solving process has a set of universal steps and that the process involves the development of knowledge parallel to that developed through, for example, the scientific method. The fact that knowledge of how something is done or accomplished relates to and often precedes higher order knowledge (Pring, 1976), is also quite a revelation to student teachers.

The Curriculum Purpose

The purpose or rationale for the teaching of technological education (Figure 4) is systematically addressed in the program. The elements of the rationale which are explored include the experiential method or process itself, personal development or fulfilment, technological enlightenment for all, and economic well-being (individual and societal). These elements are not taught as distinct topics unto themselves; instead, through year long journaling, students are invited to formulate a personal philosophy of technological education. They are asked to answer the question - why teach technological studies in schools? Journal entries are shared with faculty and methodically tailored to reflect the student's own background experience in technology. A technological education "issues" class, designed and operated collaboratively by the students and fac

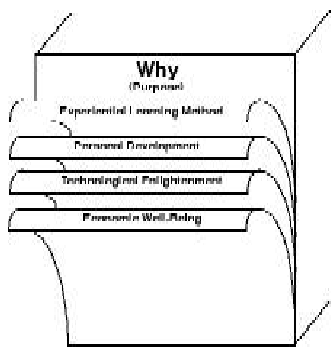

Figure 4.

ulty, augments the journaling exercise by focusing on the following: technological change, the political realities of technological education, the natural and human altered world, and the many direct and indirect connections between education and work. The works of McCormick (1990) and The Ministry of Education Committee on Technological Teacher Education (1992) are used as a foundation for discussions about a rationale for technological education.

Concluding Comments

The “output” stage is one that is overlooked by program planners because of institutional constraints. For example, constraints include budgets, lack of a systems perspective which recognizes the importance of feedback and evaluation analysis, and limited human and physical resources. At The University of Western Ontario, graduating teachers become an integral part of the program for the subsequent year's cohort of teacher candidates. First and second year teachers, through a voluntary but planned networking arrangement initiated each year by the current graduating class, organize a workshop for their protege_s during the subsequent school year. Workshop topics include the relevant but often overlooked unknowns that “would-be” teachers want to discuss with recent inductees of the profession; for example: How do you overcome public speaking anxiety? What curriculum changes did you have to make? What technological activities/projects did you conceive?

By examining the entire teacher development process from recruitment, through pre-service preparation, to the first two years of teaching, continuity from the beginning teacher's perspective, is enhanced, and program excellence is fostered. Technological education teachers, as found in the project, come to teaching with several preconceptions, some problematic, others refreshingly precious. The following are some examples of both. Acceptance of technological phenomena as either given or already determined, conventional notions of the value and purpose of skill development, the place of entrepreneurship in the technological education curriculum, subordinate role model behavior (presumably a manifestation of life in hierarchial organizational structures), the emulation of a significant other (e.g. a teacher from the past) and a distorted view of the profession (e.g. salary scales, vacation opportunities, security) are some of the preconceptions that were found to be prevalent with the cross section of students in the project. For all the preconceptions that were identified as problematic, there were others that needed to be celebrated and reinforced. Work ethic, tolerance for different learning styles and abilities, commitment to learning, and workplace and labour market understanding, are but a few of these.

The curriculum themes, “content,” “process,” and “purpose,” presented in this paper are central features of any successful curriculum. What was important for the faculty in the program described and what is important for others wishing to re-formulate their programs, is the recognition that the elements in the model are interrelated and in a continual state of flux. Furthermore, the force for program change has to be both internal and external to the student teachers who are learning. With these perspectives and a sensitivity to the many processes by which learning occurs, a chance for meaningful intervention exists.

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Technology Education in Japan

Shoji Murata & Sam Stern[1]

An Overview of the Japanese Educational System

In recent years, Japanese industrial and educational practices have received worldwide attention. In spite of the interest in Japanese industry and education, there has been relatively little study of technology education in Japan. This paper describes the history, current status, and future challenges of technology education in Japan. Because of their close relationship, discussion of both technology education at the lower secondary level, *gijutsu ka*, and vocational technical education at the upper secondary and post-secondary level, *shokugyo kyoiku*, are included in this paper.

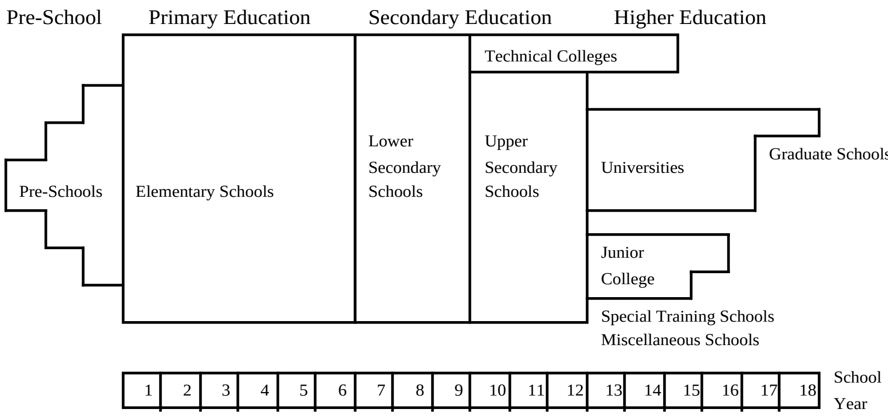

Figure 1. Organization of Japanese School System

The structure of public education in Japan is largely based on the American model of education which was adopted after World War II. Figure 1 shows the major types of publicly supported schools. The foundation of the modern Japanese educational system is the nine-year compulsory education core, *gimu kyoiku*. Included in the compulsory core is a six-year elementary school,

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shogakko, and a three-year lower secondary school, *chugakko*. Practically all (almost 100%) of Japanese students complete compulsory education. After completing compulsory education, about 95% enter upper secondary school. Of those who enter upper secondary schools, less than two percent drop out before graduating. (Ministry of Education, Science, and Culture, 1991).

With one of the highest literacy rates in the world, it is common to overlook the dramatic increase in educational attainment since World War II. Young Japanese are entering the workforce with much higher levels of formal education than ever before. In 1950, 45.2% of Japanese lower secondary graduates began working at age 15 after completing compulsory education, while 43% entered upper secondary school. As a result, the current Japanese workforce is a mixture of older workers with relatively lower levels of formal education and younger workers with higher levels of formal education.

Curriculum in Transition

Unlike America, Japan has a strong national system of education. Curricula for elementary, lower secondary, and upper secondary education is promulgated by the Ministry of Education, *Mombusho*. About every ten years, the Ministry of Education issues a new Standard Course of Study, which is a set of detailed, written guidelines for each subject taught in elementary and secondary schools. Suggestions for curricular revisions are made by various committees that include curriculum specialists, university professors, classroom teachers, members of local boards of education, and others.

Changes in Japanese technology education programs following World War II can be viewed in the context of four eras: 1) Economic Reconstruction Era, 2) High Economic Growth Era, 3) Stabilized Economic Era, and 4) International Era (Murata, 1990). Table 1 shows the socio-economic conditions that were characteristic of each era, and upper secondary and post-secondary enrollment percentages.

Establishment of Vocational Technical Education as a Required Subject

National support for vocational education in Japan has a long history. In his address to to the Diet (the popularly elected national legislature) in 1894, the Minister of Education said,

> It is clear that competition in the world is essentially industrial, rather than military. Our science has advanced satisfactorily, but not our technical training at the lower levels. This condition is like an army with plenty of good generals, but not enough noncoms. (Passin, 1982, p. 97)

His reference to the military was made in the context of the Sino-Japanese War. Later that year, the first national Vocational Education Law was passed. By 1899, agriculture, fishery, forestry, and industrial programs were established at the lower secondary level. Until 1958, vocational education was offered in

Table 1
Socio-economic development and educational enrollments

Era	Socio-Economic Conditions	Enrollment Percentage* Upper Secondary	Enrollment Percentage* College/ University
Economic Reconstruction	Shortage of housing and food.	43.0% (1950) 51.5% (1955)	10.1% (1955)
High Economic Growth	Promotion of science & technology.	57.7% (1960)	10.3% (1960)
		70.7% (1965)	17.1% (1965)
	Rapid economic growth (about 10%).	82.1% (1970)	24.0% (1970)
Stablized Economy	Oil crisis (1971 & 74).	91.9% (1975)	34.2% (1975)
	Economic growth slows and stablizes (3-5%).	94.0% (1980)	31.9% (1980)
International	Growth of microelectronics & service industry.	94.1% (1985)	30.5% (1985)
	Internationalization of economy.	94.7% (1989)	30.6% (1989)

*Ministry of Education, Science, and Culture, 1991

lower secondary schools. Since 1958, vocational education has been offered in both comprehensive high schools and in separate vocational secondary schools. Although the concept of the comprehensive high school was an objective of the American Occupation education reform, it never became the dominant pattern in Japan. About half of Japanese upper secondary schools provide only an academic program, with the remainder almost evenly divided between comprehensive and vocational schools (U.S. Department of Education, 1987). In other words, most Japanese upper secondary schools offer academic programs that prepare students for higher education, and do not offer vocational courses. Therefore most of the Japanese students who participate in vocational courses do so in vocational schools. During the 1990 school year, about 26% of upper secondary school students were enrolled in vocational education classes.

As shown in Table 1, during the Economic Reconstruction Era about half of lower secondary school graduates began work immediately after graduating. At that time, vocational education was a required subject in lower secondary schools for all boys and girls, consisting of courses related to agriculture, industry, business, and home economics. The curriculum varied from school to school depending on the school's location. One of the main goals of vocational education was career education through experiential learning.

Introduction of Technology Education

Following the successful launching of the Soviet satellite "Sputnik," Japan, like many other countries around the world, tried to improve their science and technology education programs. One of the policies adopted by the Japanese government in late 1957 was the introduction of technology education, *gijutsu ka*, as a required subject in all lower secondary schools beginning in 1958[1]. With the introduction of technology education in the lower secondary schools, vocational education was moved to the upper secondary level as an elective course.

In 1958, the major objectives of technology education at the lower secondary school were: 1) to help students learn basic skills through creative/-productive experience, to understand modern technology, and foster fundamental attitudes for practice; 2) through experience of design and realization, to foster skills for presentation, creation, and rational attitudes for problem solving; and 3) through experience in manufacturing/operation of machines/devices, to understand the relation between technology and life and to foster attitudes for improving technology and daily life. Major content areas included design and drawing; woodworking and metal working; machinery; electricity; and cultivation. A total of 105 hours in each of the three grades of lower secondary school was allocated for technology education.

In 1960, the Japanese government set out to double the number of technical high schools. During this era, five-year technical colleges for the graduates of lower secondary schools were established by the Ministry of Education. To respond to the shortage of skilled technical teachers, three-year teachers' colleges for technical education were established. These colleges were attached to Faculties of Technology at Japanese national universities. During the 1960's these colleges enrolled about 900 students each year. These policies were all related to Japan's "Doubling the National Income Program." At the beginning of this era, the *Ministry of Education* sent a curriculum specialist in technical education to the U.S. to gather information about technical-related subjects (Suzuki and Murata, 1990).

Introduction of Fundamental Subjects and Equal Opportunity in Education

Throughout the High Economic Growth Era, the percentage of Japanese students enrolled in upper secondary schools and higher education institutions continued to increase. However, the knowledge and skills needed in the workplace changed dramatically. In industry-related sectors, employers wanted workers to have greater flexibility and trainability. During this era, Ministry of

[1]The same term, *gijutsu ka,* has been consistently used to describe industrial arts/technology education classes in Japanese lower secondary school since its introduction in 1958. Gijutsu means technology and ka means subject.

Education introduced fundamental subjects to vocational technical courses and also introduced work experience activities to general courses.

In this era, issues related to equal educational opportunity in secondary education began to emerge. Until then, all male students participated in technology education classes and all female students participated in home economics classes. To provide equal educational opportunity, beginning in 1977, the Ministry of Education required all male students to take at least one home economics class and all female students to take at least one technology education class.

In upper secondary schools, students enrolled in vocational technical education were required to take fundamental subjects such as “Fundamentals of Industry,” “Mathematics in Technology,” and “Practice.” The goal of these subjects was to improve students' fundamental knowledge and skills, as well as accommodate new teaching materials and methods (Tamura, Arai, and Murata, 1985). At that time, work experience activities were introduced into general courses for all students.

Introduction of “Fundamentals of Information” into Lower Secondary School and “Independent Study Project” into Upper Secondary School

To respond to changes in the workplace and society, the Ministry of Education initiated several changes in the late 1980's. One of the major changes was the inclusion of a new computer literacy course in technology education programs in lower secondary schools. The primary objective of the new course is to help students understand the roles and functions of computers, and develop capability for the use of computers and information. Major content areas include computers and society, computer hardware, computer software, and application of computer software.

Although the new computer literacy course is not one of the four required courses (woodworking, electronics, home life, and food), it is one of the most popular elective courses. According to a study by the Ministry of Education (1991) 76% of all students want to take the new computer literacy course.

In the upper secondary school level, the Ministry of Education revised technical courses to encourage the development of basic skills and flexibility. In general subjects, the Ministry of Education encouraged the use of computers in science and mathematics. All vocational students are required to take a new information technology subject related to their major course, such as agricultural information processing and home economics information processing. One of the most significant revisions in upper secondary technical courses is the introduction of integrated problem solving courses, such as “mechatronics,” “applied mechatronics,” and independent/assignment project study.

The primary objective of the new mechatronics course is to promote the understanding of fundamental knowledge and skills related to mechatronics (a combination of mechanics and electronics). As shown in Table 2, content areas include basic machines and devices, sensors, A/D conversion, logic circuits, actuators, mechanics, and power transmission devices.

Table 2
National Course of Study Example

Objective	Contents
Mechatronics. To understand fundamental knowledge and develop skills related to mechatronics, and to foster the ability to apply them in a practical setting.	1) Integration of electronics and mechanics in machines and devices. 2) Principles and characteristics of sensors. 3) Sensors and computers; analog digital conversion, logic circuits, and signals. 4) Types and characteristics of actuators. 5) Actuator control. 6) Mechanics and power transmission devices.

In general, there has been a movement toward a broader view of technology education and vocational education in Japan. However, a broader and less “subject-specific” approach can result in a relatively shallow educational experience. The primary objective of independent project study is for students to deepen and integrate knowledge and skills through problem solving and industrial projects. Major content areas include design, manufacture, research, experimentation, the study of workplace practice, and acquisition of professional/vocational certificates. Examples of projects include the design and manufacture of robots and remote control models (Murata, 1990).

Technology Education Teaching Methods

From the beginnings of technology education in Japan, the primary teaching methodology was experiential, based on the project method. Technology education classes in Japan are typically organized into lecture and practice classes. Practice classes (laboratory work) usually have less students than lecture classes. The average class size in Japan is approximately 40 students. More recently, new types of project activities have been introduced that attempt to integrate different technical areas and lecture content.

Support for Technology Education

The Vocational Education Promotion Law was enacted in 1951. As a result the national government, through the Ministry of Education, was obligated to promote vocational technical education and encourage local governments to support facilities for vocational technical education. After the development of each Standard Curriculum, the Ministry of Education promulgated technology education and vocational technical education equipment standards. The national government provided subsidies to upper secondary schools that amount to approximately one third of the budget for vocational technical education facilities and equipment. As authorized by Vocational Education Allowance Act of 1957, upper secondary vocational teachers at national and public schools receive a special monthly allowance equal to 10% of their monthly salary.

Initial and In-Service Teacher Training

Initial teacher training for technology education and vocational technical education primarily occurs in the Engineering Colleges or technical education departments of national universities. Because of rapid changes in technology it is often necessary for technology education and vocational technical education teachers to be retrained. After each major curriculum revision (usually a ten-year cycle), the Ministry of Education plans and implements in-service training programs. A good example is the major in-service effort to prepare the approximately 16,000 Japanese technology education teachers to teach the new course on computer literacy. In the first stage of the in-service program, about 160 technology teachers received two weeks of full-time in-service training. Over a three-year period, a total of 480 such "lead teachers" received similar training. In addition to the two weeks of intensive training, these teachers assume personal responsibility for self-study about computers. Each newly retrained teacher returned to their district and began training other technology teachers in their district. In-service training at the district level continued for four years (1988 through 1992) providing in-service training to all technology education teachers in Japan (Stern and Matsuda, 1988).

Educational Centers for Technology Education

Every one of the 47 prefectures (regional self governing bodies) in Japan has an education center that includes a department of technology/industry-related education (including information technology). Some of the large prefectures have independent centers for information technology or technical education. These educational institutions serve several functions including teacher retraining, development of teaching materials, and research on educational methods. In order to use prefectural educational budgets effectively, educational centers are equipped with expensive facilities such as large scale computer systems and machining centers.

Textbook Approval and Subsidies for Compulsory School Textbooks

All textbooks used in compulsory schools and most upper secondary schools are compiled and published by private publishing companies, and subject to approval by the Ministry of Education. All compulsory school textbooks, including technology education textbooks, are provided to students at no cost. The textbooks, which are typically softcover and well illustrated, are designed to be compatible with the Standard Course of Study as outlined by the Ministry of Education. By way of example, an approved mechatronics text would have material directly related to each of the content areas identified in Table 2.

Challenges Facing Technology Education in Japan

The following are four major challenges facing technology education in Japan. How well Japan is able to meet these challenges will determine the nature and effectiveness of technology education in the future.

Entrance Examination Pressure

Highly competitive entrance examinations are an important aspect of education in Japan. Especially important are the university entrance examinations which determine which students will be accepted at prestigious Japanese universities. Since admission to prestigious universities will result in various lifelong advantages, parents encourage their children to begin preparing for entrance examinations at an early age. The national university examinations cover five major areas: mathematics, Japanese, English, natural science, and the humanities. The entrance examination does not include content from technology education, home economics, fine arts, or health education. As a result, Japanese parents tend to regard these subjects as subordinate to subjects that are included in the entrance examinations. The influence of parents is strong, affecting the attitudes and actions of students and teachers.

Difficulty of Curriculum Change

The ten-year intervals between major curriculum change are too long to reflect changes in technology and in the workplace. This is an especially important challenge for technology education, since the content of technology education is closely related to the world of technology and the world of work.

Technology Education and Equal Opportunity in Education

Japan is beginning to experiment with a shorter work week and shorter school week. During the 1992-93 school year, Japanese schools will not have classes on one Saturday per month. As a result there will be less time available for instruction. There is widespread concern that in response to entrance examination pressure, many students will use the extra time to attend cram schools, *juku*. The reduction in school time poses an especially important challenge for technology education and home economics education. To provide equal access to boys and girls, the Ministry of Education decreased the time allocated to technology education and home economics by 50%. Although more students, both boys and girls, participate in technology education and home economics, they spend less time in each area.

Lack of Resources for Technology Education

As in other countries, technology education in Japan is constrained by a lack of resources, both financial and human. Technology education requires continuing financial investment in facilities, equipment, and materials. More importantly, it is becoming increasingly difficult to recruit good technology education teachers. Many engineering and technology graduates are recruited by companies, leaving relatively few available to work as technology education teachers.

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Implementing Technology in the School Curriculum: A Case Study Involving Six Secondary Schools

David F. Treagust & Léonie J. Rennie[1]

In Australia, economic, social and educational pressures have led to increasing importance being placed on technology education, just as has happened in other countries (Medway, 1989). The importance of technology in the school curriculum of every secondary student has been strongly advocated (Vohra, 1987) and in the USA the goals of an effective curriculum have been delineated (Fricke, 1987). Even so, how technology will be incorporated within the curriculum and who shall teach technology is not resolved (Gardner, Penna & Brass, 1990). There is a move away from aligning technology with the 'trade' or 'technical' subjects and an effort to place it more central to the curriculum. However, how this will be done is still a source of great debate. In England too, there has been considerable tension about which of the subjects in the school curriculum should take technology within their realm (Woolnough, 1988).

In their review of technology education in schools, Allsop and Woolnough (1990) explain that technology has developed along four different lines, each with its own traditions and character. One approach is that dominated by craft teachers, a second is an approach focusing on hi-tech advances such as computers and electronics, a third approach presents technology as an engineering course at the secondary level, while a fourth views technology as a subset of science. Fensham (1990) has described how science education has gained an increasingly technological perspective in the 1980s and 1990s, and the word 'technology' is mainly used by science educators to refer to applied science (Rennie, 1987), a perception not shared by most industrial and craft teachers. Certainly science teachers can play an important role by teaching technology as applied science, by modifying courses in formal ways, say Engineering and Science instead of Physics, or by extending the science curriculum to involve the design and completion of an investigational or constructional project (Black & Harrison, 1985). However, a more comprehensive view of technology education considers it to comprise four components of technological literacy, techno-

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logical awareness, technological capability and information technology (Woolnough, 1988), some aspects of which can be taught by all departments in a school.

Recently, and in recognition of the wider educational role technology can play, the Ministry of Education in Western Australia invited schools to submit proposals for the incorporation of technology in their curricula. No specific brief was given to schools, rather they were expected to plan programs which utilized the expertise of their staff, met the needs of their students and were integrated within the context of the local community.

Out of 21 submissions, six successful schools were designated as Technology Schools by the Ministry. They received appropriate funding to implement their proposals during 1988 and 1989 and each school appointed a person as technology coordinator to supervise the implementation. Four of the schools were large senior high schools with between 700 and 1500 students in Grades 8 to 12. Two were in a metropolitan city with over one million people, one in an agricultural district and one in a mining community. Two smaller district high schools had students in Grades 1 to 10: One in a remote area had almost 300 students, many of Aboriginal descent; the other with about 200 students was in an agricultural area.

As might be expected from six schools in different locations and with different clientele, the proposals differed widely in terms of the intended foci and curriculum adaptations to incorporate technology, and also in the perceptions of technology on which these adaptations would be based. Consequently, schools spent their money in different ways. Some schools allocated most of their funds towards the employment of temporary teachers so that regular teachers could have part-time release for planning, inservice and curriculum writing; other schools invested in equipment around which their technology proposals would be implemented.

This paper reports an evaluation of the approaches and programs implemented in the six technology schools. The findings are important, not only because technology education is of increasing interest and these technology-based initiatives were the first to be undertaken in Western Australian schools, but because the identification of successful implementations of technology can provide guidance for other schools wishing to introduce technology in their curricula.

Method

The evaluation approach was based on the framework originally enunciated by Stake (1967): judging success or failure of the implementation based on the congruence between the intents of the program and observations of what eventuated. The effectiveness of the implementation process was evaluated in terms of (a) the intended curriculum, defined by the way technology was presented by the written statements of policy, the syllabi and the teaching materials;

(b) the implemented curriculum, defined by the manner in which the schools incorporated technology into their programs; and (c) the achieved curriculum, defined in terms of the degree of match between the intended and implemented curriculum. Emphasis was placed on description of the schools' programs, in terms of the context (antecedents) and process (transactions) in each program, rather than on student outcomes, an approach which recognized that outcomes rarely guide change (Stake, 1991). Further, cognizance was taken of the gradual adjustments school staff made on the basis of their experiences as their implementation progressed.

The evaluation was designed as a multi-site case study (Merriam, 1988) with data collection in two stages. Schools received funding for their proposals during the 1988 calendar year for the implementation of their programs during 1988 and 1989. The first data collection occurred at the end of the 1989 school year, and the second at the end of 1990, to examine the extent to which the programs had continued. Data were collected by questionnaires, interviews and document analysis. Questionnaires were given to the technology coordinators, to the teachers involved in the implementation process and to the students who experienced the implemented curriculum. During visits to schools, the coordinators and teachers were interviewed and curriculum documents related to the schools' original proposals and to their continuing technology programs were examined.

Questionnaire Data

Technology Coordinators. Two open-ended questionnaires were administered to the technology coordinators, one towards the end of 1989 and the other towards the end of 1990. The first questionnaire dealt with the intended and actual implementation of technology in the school, staff planning and communication, resources, financial arrangements and other matters perceived by the coordinators to be important. The second questionnaire had two parts. The first part asked for reactions to the technology coordinator's own statements made in the previous year in light of the implementation process during the current year. The second part asked for the technology coordinator's own summative evaluation of the project.

Teachers. Towards the end of 1990, teachers involved in implementing technology were asked to provide details of any changes they perceived to have taken place in their teaching and in the curriculum materials they were using.

Students. Because of the variation in the approaches taken by the schools, there was no consistent pattern of expected performance-related outcomes for students which could be used as a basis for assessing change in student performance. Further, as described previously, the focus of the evaluation was on the context and process of curriculum change rather than on student outcomes. Nevertheless, a questionnaire which measured attitudes toward, and perceptions about, technology was used in an attempt to detect any general change in these variables which could be associated with the implementation.

The instrument, called the *Attitudes and Perceptions About Technology* (APAT) questionnaire, consisted of 31 Likert-type items in seven subscales, namely, Interest in Technology, Careers in Technology, Technology is Easy, Importance of Technology, Technology as a Design Process, Diversity in Technology, and Technology as Problem Solving. The questionnaire was based upon previous research into students' ideas about technology, particularly the cross-national studies coordinated by the Pupils' Attitudes Towards Technology (PATT) project in the Netherlands (Raat & de Vries, 1986; Raat, de Klerk Wolters & de Vries, 1987; Raat, Coenen-van den Bergh, de Klerk Wolters & de Vries, 1988; de Klerk Wolters, 1989; de Klerk Wolters, Mottier, Raat, & de Vries, 1989). By using the comprehensive framework developed in the PATT studies, which were not tied to a particular curriculum, it was possible to examine a wide range of possible attitudes and perceptions about technology. Trials of the questionnaire included adaptations in wording to suit local curriculum for an age range of 11 to 15 years. The development and validation of the instrument is described by Rennie and Treagust (1989).

The student questionnaires were administered in five of the six schools towards the beginning and end of 1990. For each scale, items were coded so that higher scores represented more positive attitudes. Reliabilities ranged from .63 (for the two-item Importance scale) to .89 (for the seven-item Interest scale) in this study. Statistical comparisons between the pretest and posttest were made using a repeated measures design for analysis of variance.

Visits to Schools

The evaluators visited country schools once, and metropolitan schools several times to discuss the implementation process with the coordinators, teachers and students. The visits were used as opportunities to confirm or refute data collected by questionnaires and also to examine relevant curriculum documentation in the schools.

Results

Each of the six Technology Schools adopted its own approach to technology. The plans for technology implementation were affected by the location of the school, variations in the size and nature of its student population and the community context. Underpinning these different approaches were differences in perceptions about the nature of technology held by the staff which were discernible in the kinds of curriculum change intended, the way these changes were being implemented, and the distribution of funds to support them. The results of the evaluation of these different programs are reported in Table 1 as a summary of the major findings of each school's intended, implemented, and achieved curricula concerning technology. The summaries for each school are expanded and important points drawn together in the ensuing discussion.

Eastern Metropolitan Senior High School

This school of almost 700 students serves a predominantly working class, multi-cultural community. This school chose the working definition for technology adopted by UNESCO (Vohra, 1987), namely, that "Technology is the know-how and creative process that may utilize tools, resources and systems to solve problems to enhance control over the natural and man-made [sic] environment in an endeavour to improve the human condition" (p. 415). The implementation of curriculum change based on such a perception of technology was directed towards developing a range of skills, including thinking skills, and encouraging students to use those skills when confronted by new or problem situations. At the outset there was considerable debate among senior teachers about the best approach to take. There was a belief that to be successful, the program had to be implemented on a school-wide basis, because a fragmented approach in a few subjects was unlikely to provide sufficient opportunity for the skills to be learned and practiced. Further, students needed to have experience using the skills to appreciate their transferability to different situations. The adopted model included the four aspects of technological awareness, technological literacy, information technology, and technological capability (Woolnough, 1988), as well as transferable (problem-solving) skills, each of which could be integrated in different areas of the curriculum. Teaching staff in different subjects could then contribute to this model by writing suitable teaching objectives for their own subject areas. Details of how this was done are described by Treagust and Mather (1990).

Because it adopted a whole school approach to implementing technology, Eastern Metropolitan Senior High allocated nearly all of its funds to teacher release, allowing the coordinator to fulfil her leadership role and teachers to write or modify their own curriculum. Other money was spent on resources such as books and audiovisual materials. Except for a small amount of release time for the coordinator in 1990, the school's project funds were used by the end of 1989 and the costs related to maintaining the technology program have come from other sources. Despite the loss of several key people over the last three years and changes of Principal, the technology program has continued with two discernible thrusts. The first is technology as a design process or problem-solving approach which appears as an integrating theme across subjects, and the second is the modification within prescribed curriculum objectives to emphasise the products and impact of technology on society. The findings from the APAT student questionnaire were consistently positive, but few of the pretest-posttest differences were statistically significant. Eastern Metropolitan Senior High judges itself to have been successful in its technology

Table 1
Major Findings for the Six Technology Schools in Terms of Their Intended, Implemented and Achieved Cur

School	Intended	Implemented Curriculum	Achieved Curriculum
Eastern Metropolitan Senior High	• Technology as a human process involving thinking and problem solving. • Technology to be integrated on a school-wide basis by means of a curriculum focused on the development of appropriate technological skills. • Introduction of computing on a school-wide basis.	• Development of teaching and learning strategies for introducing technology across the curriculum. • Technology objectives integrated into most subjects throughout Grades 8 – 10. • Activities coordinated by, but not solely dependent on, the coordinator. • Contacts with local industries and businesses pursued. • Computers used by all students in the school through the Information Technology Center.	• Few significant pretest-pos questionnaire for Grades 8–1 • Highly visible contacts out •Definite ethos of a technolo almost all faculty. • The intended curriculum ha and well articulated approacl
Southern Metropolitan Senior High	• Technology as a human process involving thinking and problem solving. • Integrate technology as a way of thinking within some subjects and as a means to change teaching methods. • Introduction of computing on a school-wide basis.	• Technology focus and/or objectives introduced in some subjects but not coordinated within or between departments, except Social Studies. • Activities initiated by interested staff in conjunction with coordinator. • Activities coordinated by, but not solely dependent on, the coordinator. • Computers used by all students as part of their program.	• No substantial APAT quest scores for Grades 9 and 10. I increase in Possibility of a C Importance of Technology. I 9 and 10 were smaller than i • The intended curriculum ha several subject areas within t • Highly visible computing p venture with large computer

Table 1 (cont.)
Major Findings for the Six Technology Schools in Terms of Their Intended, Implemented and Achieved Cur

School	Intended	Implemented Curriculum	Achieved Curriculum
Rural Senior High	• Technology as the human attempt to deploy matter, energy and information. • A variety of projects to be developed with the goal of enhancing technological literacy across all subject areas.	• Technology introduced in most subjects in lower school at some level. • New technology equipment purchased and installed. • Emphasis on technology projects in Science and Industrial Arts. • Activities facilitated by coordinator who has remained in the school and continues in this capacity despite no further Ministry funding.	• No substantial APAT que difference scores for Grade statistically significant dec of Technology and that Te • Technology focus highly less so in others. • Most intended aspects su some with substantial dela • Definite ethos of a techno most faculty.
Country Senior High	• Technology as the application of appropriate science to jobs in order that they can be completed more easily. • Different subject areas to develop technological themes.	• Two new Science units in lower school with an emphasis on mining. • Electronics and robotics taught in Industrial Arts. • Some aspects of technology introduced in Business Studies but not maintained. • Activities dependent on initiating coordinator who left the School at the end of 1989.	• No substantial pretest-po APAT questionnaire for G Technology as Problem So previously. Grade 10 score • Only Science and Industr activities but those are not • Lack of a coordinator me exceptions, the intended cu • Almost no awareness of t teachers in other subject ar

Table 1 (cont.)
Major Findings for the Six Technology Schools in Terms of Their Intended, Implemented and Achieved Cur

School	Intended	Implemented Curriculum	Achieved Curriculum
Remote District High	• Technology as a change agent in society. • Five projects to be developed and integrated into different curriculum areas. • Computers introduced into the Library and Secretarial Studies for word processing.	• Activities highly dependent on initiating coordinator who left the School at the end of 1988. • The Low Technology Project is implemented. • Attempts to have one computer per classroom, but use of computers in the School ineffective.	• No APAT questionnaire da • The Low Technology Proje one teacher – students report • Lack of coordinator means exception of the above, the ir was not achieved.
Central District High	•Technology as a human process involving thinking and problem solving. • Technology to be integrated as a whole-school approach with emphasis on computer applications. • Computing and Desk Top Publishing offered in Grades 8-10.	• Links made with the community by offering Technical and Further Education Subjects • Computing equipment purchased and installed in the school. • Desk Top Publishing and Computing offered but few students take these subjects. • Activities highly dependent on initial coordinator who left the School at the end of 1989.	• APAT questionnaire results show that attitudes are gener size too small for tests of sig • Current lack of a coordinat intended curriculum has cont • Technology Project 'on hol future School Development I

implementation, and has assigned the task of maintaining the technological impetus to a designated staff member. In addition, a Technology Information Centre equipped by a partnership with a large computer company, and an innovative Fashion and Design curriculum stream, are projects which have resulted from the supportive environment in the school.

Southern Metropolitan Senior High School

This large metropolitan school caters for over 1,400 students from a middle class community. The school adopted the same UNESCO definition of technology as Eastern Metropolitan Senior High and implemented technology on a school-wide basis. Most of the funds for the technology project were directed to releasing teachers from teaching duties. The technology coordinator had full-time release for part of the life of the original period of funding to help other teachers develop their ideas and to teach classes while teachers worked on curriculum modifications. The coordinator expressed concern at the end of 1989 that implementing a technology philosophy school-wide was a difficult and generally new process, because it took a long time for teachers to accept the rationale underlying the technology implementation.

By the end of 1990 it was evident that technology had been included in many subjects across the curriculum. In some subjects, technology was viewed as a way of thinking to solve problems and change teaching methods which enabled students to develop thinking skills. In addition, the school has an extensive program centered around computing as a result of its joint venture with a major computing company. A range of school-based initiatives have created an atmosphere supportive of change and technology became a focus for that change. Gains made by Grade 8 students, but not others on the APAT questionnaire, suggested that technology was particularly influential when students entered the school.

Rural Senior High School

This country school had an enrolment of about 800 students from agricultural communities. The school adopted a definition of technology which emphasized the human attempt to deploy matter, energy and information and the intended curriculum included a wide variety of projects to develop technological literacy across all subject areas. Emphasis was placed on understanding science and technology and their effects on society. About two thirds of funds were committed to the purchase of hardware and technical support for it, and curriculum modifications were made in nearly all subject areas.

By the end of 1989, when the original funds were spent, progress had been made in most areas except a satellite remote sensing project where software problems were not solved for nearly two years. Despite nearly all the technology initiatives having been implemented by 1990, the students' responses to the

APAT questionnaire resulted in no statistically significant gain scores. Aside from the computer-related problems, most delays were caused by lack of time to make the curriculum modifications. The continuation by the school with its program could be attributed to the sense of school staff ownership of the program and the continuing presence of, and direction given by, the technology coordinator even though funds for his release time were not available in 1990.

Country Senior High School

This school is in a mining area distant from the metropolitan area, where many of its approximately 1000 students are transient and there is a large staff turnover each year. The school focused on technology as the application of "appropriate science" to jobs in order for them to be completed more easily and involved teachers from different subject areas to develop technological themes – in Industrial Arts, Science, Library Studies and Media. Its funds were divided between teacher release for curriculum modifications, appropriate equipment, and travel (including part-purchase of a bus for student transport to off-campus activity sites).

Two new Science curriculum units relating to mining were introduced in Grades 9 and 10 and input was sought from mining personnel to assist teachers make the curriculum changes. Technology was considered to be integral to the Industrial Arts program and one of the teachers taught electronics and robotics as technology-based units. A notable feature of the APAT student scores was that the most positive results were in Grade 10, perhaps reflecting the introduction of these new units in Grades 9 and 10. Since its specific funding for technology ceased in 1989, Country Senior High has continued to pursue technology in Science and Industrial Arts, but there has been no sense of school-wide acceptance that the school is a Technology School.

Remote District High School

This small school of less than 300 students is in a very remote part of Western Australia, has frequent staff changes and a high percentage of Aboriginal students. Partly because of frequent staff changes, students did not complete the APAT questionnaire. Technology focussed on changes in society and the school's intention was to integrate five projects in different curriculum areas. Four of the projects began, but a large staff turnover (including the original technology coordinator) between 1988 and 1989 resulted in only two projects remaining: the use of computers for both staff and students and a Low-Technology pastoral project. The teacher in charge of the Low-Technology Project is the 'lone survivor' of the early technology planning, and this was the only technology initiative which remained through 1990.

Central District High School

This small country school enrolled approximately 200 students in an agricultural area. It adopted a whole school approach to technology based on the UNESCO definition (Vohra, 1987). The school purchased a computer incorporating CD-Rom to improve resources for research and equipment for desktop publishing and all students were given opportunities to use these facilities as part of their normal subjects. About half of the technology funds were used to purchase equipment and about a quarter used for teacher release. All staff attended inservice sessions in 1988 and 1989 to deal with curricular aspects of technology implementation and use of the new equipment. Students' responses to the APAT questionnaire indicated very positive attitudes; however, with small numbers of students in each grade no tests for statistical significance were carried out. In 1990, the technology program was put ‘on hold’ because the rural recession and falling student numbers affected the viability of timetabling some curriculum units.

Discussion

Were the intended curricula implemented and intended outcomes achieved?

The results of the evaluation suggest that three schools achieved, to some extent, their intended objectives as a Technology School. These schools – Eastern Metropolitan Senior High, Rural Senior High and Southern Metropolitan Senior High – each have particular features that may be instructive to other schools wishing to implement technology education. Three schools were unable, for one or more reasons, to fulfill their intended objectives to become a Technology School. While these schools - Country Senior High, Remote District High and Central District High - were unsuccessful in achieving all of their objectives, there were several important aspects which contributed to this situation. Careful analysis of these aspects can identify potential obstacles for schools attempting school-based technology curriculum change.

What obstacles prevented the intended outcomes being achieved?

In the three unsuccessful schools, the major factors preventing achievement of the intended outcomes were the high degree of dependency of the project on the initiator and original coordinator, the high turnover of the staff, and the lack of articulation between new staff and those leaving the school. In all three schools, the initial technology coordinator was able to implement the intended activities in the short term, but because these activities were so dependent on him or her, once he or she had left the school, various aspects of the projects were not continued.

At Country Senior High School, some technology initiatives remained in Science and Industrial Arts although there was no coordination between the two subject areas. The teachers involved realised the need to provide some overall coordination, as did the newly appointed Principal in 1990, but no decision was made to finance such a position within the school. Remote District High had a viable technology initiative in the Low-Technology Project which was dependent on one staff member who had been at the school for a number of years. The other projects in this school have not continued because there was no communication between outgoing and incoming staff to the school, especially between the initial outgoing Deputy Principal who was the technology coordinator and her successor. Central District High made the decision to officially place the technology project 'on hold' since there was no relevant expertise within the school's present staff.

What aspects contributed to successful outcomes being achieved?

The success of the technology implementation was dependent on effective communication among staff and the devolution of responsibility for the intended curriculum change from the coordinator to the individual teachers and/or departments in different subject areas. Effective communication and devolution of responsibility were most successful at Eastern Metropolitan Senior High, where, as a result of an overall school-coordinated approach, almost all subject areas of the school curricula were involved in technology education. A feature of the technology program in this school was the high level of communication among the staff. Throughout the implementation period, the coordinator had frequent meetings with an advisory board of senior staff in the school and some outside persons. Further, the coordinator remained knowledgable about developments in different subject areas by meeting frequently with key staff and organizing teacher inservice sessions to help teachers do the work for which they had made a commitment. Eastern Metropolitan Senior High's approach to technology implementation illustrated its strength at the end of 1989 when the original coordinator was transferred from the school but momentum continued because of effective communication and support within the school. The decision to develop and implement an approach which involved all teachers of all subjects, to a greater or lesser extent depending on their interests, appears to have been compatible with the working environment in the school.

The strength of the devolution approach was also evident at Southern Metropolitan Senior High which has a very large staff. The Principal was highly supportive of the technology focus of the school and took a leadership role in expanding the computing aspects of the curriculum. The technology coordinator assisted individual teachers implementing some aspect of technology into their curriculum and this personal approach did appear to be at least partially successful. However, when this was done without coordination between subject staff, the focus of that initiative was lost if the teacher left the school. The Social Studies Department had a coordinated approach in all units at all levels of the school and the emphasis was to use technology as a way of thinking, involving problem solving and critical analysis.

When the initial coordinator was on leave during 1990, the focus of the implementation was retained though there was reduced activity, partly because of staff transfers in some subject departments and the alternative coordinator for 1990 only had partial release time from teaching. However, because staff in some subject areas had already begun to change their teaching methods to focus on technology objectives, these initiatives were able to continue. The active involvement of the technology coordinator with teachers throughout the school and his continued presence (or the role being taken over by someone else in his absence) contributed greatly to the school addressing many of its intended objectives. It is conceivable that, for example, Country Senior High would have achieved much greater success in meeting its technology objectives if a person had taken over the role of technology coordinator either temporarily or permanently once the initial coordinator had left the school.

The devolution approach at Rural Senior High was also effective. The technology coordinator played a key role in planning the original submission for the school to be a Technology School and activities were coordinated and monitored by him during their implementation, though in 1990 he had less time to devote to the project due to his other responsibilities as Relieving Deputy Principal. Progress during 1990 could not have continued had the staff turnover been as substantial as that at Remote District High School or Country Senior High School. The technology focus of the school comprised separate initiatives administered by individual departments with the coordinator ensuring that these activities received visibility among all members of the school community. This visibility was apparent through a regular newsletter to keep teaching colleagues informed of technology activities and happenings throughout the school and through activities such as the "Technology Week" held in October each year. During this week different activities took place each lunchtime for the staff and students to observe and student groups visited local primary schools to explain and demonstrate science and technology activities.

There was a perception among teachers in all three successful schools that "this is a Technology School and we are doing something different and important with our programs compared to other schools". Once the focus on technology in the school was sufficiently clear, and when some teachers other than the coordinator had success with and responsibility for what they were doing, then there was sufficient momentum in the school to ensure that, with monitoring, encouragment and assistance by the coordinator, the implementation process would continue. Both Eastern and Southern Metropolitan Senior High Schools have developed a status within their community as a 'Technology School' in relation to the visible joint ventures with large computer companies. The funding for this aspect of their technology focus did not come directly from the original Ministry of Education grant, but the funds acted as seed monies to provide climates within the schools which were receptive to such joint ventures.

Conclusion

The concerns about how and where technology can be implemented within the school curriculum have been partially addressed by the six schools who were designated Technology Schools by the Western Australian Ministry of Education. The four larger schools attempted to introduce technology on a school-wide basis with varying degrees of success. At Eastern Metropolitan, Southern Metropolitan, Rural and Country Senior High Schools, the science department in each school introduced technology into their curricula, mainly as applied science, but certainly dealing with aspects of technological capability. At Remote District High School, the Low-Technology Project has a science orientation with its focus on the local pastoral industry. The schools which were most successful at introducing technology into the curriculum involved many, or most, departments in the school. These departments incorporated those aspects of technology into their curricula which were considered to be most relevant to their subject areas. Only Eastern Metropolitan High School developed objectives based on the four components of technology education described by Woolnough (1988).

Overall, the results of the evaluation have identified three major factors crucial for success of the school-based curriculum initiatives in technology education. First, there is a need for continuous coordination by someone who has the resources (particularly time) to reflect about, and maintain an overview of, what is happening in the school. Second, there needs to be thorough documentation about what is intended and what is happening, so that faculty (particularly new faculty) are kept informed about direction and progress. Finally, success requires time, time for the faculty to accept ownership of the program, time to plan modifications to their curricula and teaching strategies, time to implement those changes, and time for them to be reflected in student outcomes.

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Identifying Critical Issues and Problems In Technology Education Using A Modified-Delphi Technique

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The need to plan for the future is critical to the overall health of any organization. However, planning is often biased by the opinions of a select group of individuals who may not possess the knowledge and/or empirical data to formulate a plan that could address the most critical current and future concerns and issues facing the agency/institution. Most educational planning is designed for the short term (i.e., semesters, academic year) and involves establishing specific policies and procedures, often having little to do with vital targets that could be made operational for the medium and long range futures of the institution/agency. Strategic planning on the other hand, is designed to aid decision makers in making important changes based on strategically driven decisions (Goodstein, Nolan, & Pfeiffer, 1992). That is, in order to make strategic decisions, a strategic plan must be in place. Therefore, strategic planning is "the process by which the guiding members of an organization envision its future and develop the necessary procedures and operations to achieve that future" (Goodstein, et.al., 1992, p. 3).

Gup (1979) perceived strategic planning to be based around three distinct yet basic questions, (1) Where are we going?; (2) What is the environment?; and (3) How do we get there? The first question revolves around the stated mission of the organization. Establishing the overall purpose of the educational agency or institution sets the direction for all activities. The driving concept and philosophy should be specified so there is a clear understanding of what "business" the organization is seeking to accomplish. In answering the second question, the decision makers must determine those factors which impact on the organization. What are the opportunities, hazards, and issues that influence the success or failure of the organization? If decision makers are to make reasonable efforts in projecting their organization forward, they must accurately identify the mechanisms that will aid them in accomplishing their objectives and/or the obstacles that may prevent them from accomplishing their objectives. The third

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question, “How do we get there?” seeks to identify the approaches that could be used to successfully accomplish the mission of the organization.

Considerable effort has been made by the International Technology Education Association (ITEA) in establishing a professional improvement plan (International Technology Education Association, 1990). This strategic plan lists the six major goals of the association, followed by a number of objectives and strategies designed to establish a mechanism to aid in the accomplishment of the primary goals. Even with the professional improvement plan in place, the question must be asked, “Is this the environment of technology education?” Were the identified goals of the strategic plan established by an exhaustive evaluation of the critical issues and problems that are facing the profession currently? How assured are we that the goals and objectives identified on the professional improvement plan can solve the problems and issues facing the profession in the future? Waetjen (1991) building a case for research within technology education, states:

> Die-hards claim that research isn't needed and instead offer up dozens of anecdotal accounts of students who have benefitted from taking courses in technology education. But no matter how titillating the anecdotes, they simply do not convince deans, superintendents and boards of education. Only research results will be convincing. Research has moved from the periphery to the very core of the educational process. Indeed, research has established itself as a primary vehicle by which change is promoted and effected in education. Research now has a major impact on the focus, direction, and development of all aspects of education - and properly so. Can technology educators ignore this powerful force that increasingly will shape educational decisions? (p. 3).

“Technology Education: Issues and Trends” was the theme of the 1985 Technology Education Symposium VII. Donald Maley, keynote speaker at the symposium, addressed a series of perceived issues and trends for the technology education profession. Lin (1989) conducted research to investigate the nature of the current technology education movement and its impacts, problems, directions, as well as prospects for the future development of technology education. Other authors have identified current issues, trends, and problems impacting on the field (i.e., Lauda, 1987; Smalley, 1988; Wenig, 1989). In 1984 the American Industrial Arts Association - Board of Directors identified “Ten opportunities which will advance the profession the most”. The efforts of these individuals presented perceptions of problems and issues for technology education. They were identified through individual and/or group experiences that have relevance and may be accurate, they should not be dismissed. However, no research-based evaluation has been conducted that systematically identifies the critical issues and problems for technology education. Therefore, if the classroom teachers, teacher educators and the supervisors/administrators of technology education hope to direct the profession into a desirable future they must understand the issues and problems that will influence the success or failure of technology education. Anyone can have opinions about the field of technology education. However, such opinions are subject to individual bias and may not support empirical data. The need to gather empirical data to accurately identify the critical issues and problems facing technology education is crucial to the future of this profession.

Purpose of This Research

The purpose of this research was to determine the present and future critical issues and problems facing the technology education profession. A critical issue was defined as: Of crucial importance relating to at least two points of view that are debatable or in dispute within technology education. A critical problem was defined as: A crucial impediment to the progress or survivability of technology education. The term "present" was defined as: The current conditions under which the technology education profession is operating. The term "future" was defined as: A projected period of time of 3-5 years in the future. This span of time was judged as appropriate based on current strategic planning procedures used by the ITEA (5 year increments).

Based upon identified critical issues and problems the leadership of the technology education profession could more accurately design a path to achieve the primary mission of advancing technological literacy.

The following research questions were developed for investigation:

1. What are the critical issues that are currently impacting on the technology education discipline?
2. What are the critical problems that are currently impacting on the technology education discipline?
3. What are the critical issues that most probably will impact on the technology education disciple in the future (3-5 years)?
4. What are the critical problems that most probably will impact on the technology education discipline in the future (3-5 years)?

Methodology

Identifiable issues and problems were collected from a group of technology education professionals using the Modified-Delphi Technique designed by Dalkey and Helmer (1963) and revised by Delbecq, Van deVen, and Gustafson (1975). The primary objective of a Delphi inquiry is to obtain a consensus of opinion from a group of respondents (Salancik, Wenger and Helfer, 1971; Rojewski and Meers, 1991). Delbecq, et al. further state: "Delphi is a group process which utilizes written responses as opposed to bringing individuals together" (p. 83). Additionally, Rojewski and Meers (1991:11) stated that:

> Typically, the Delphi technique is used to achieve group consensus among participants. Consensus is determined using the interquartile range of each research priority statement. Interquartile range refers to the middle 50% of responses for each statement (i.e., distance between first and third quartiles).

This study used a four round Delphi process to ascertain and prioritize the critical issues and problems in technology education. Descriptive and ordinal level data collection and analysis was used to interpret group suggestions and opinions into a collection of descriptive information for decision making.

Population

The group selected for this study was composed of 25 panelists from 15 states and the District of Columbia. They represented technology education through three distinct groupings: seven secondary classroom teachers, nine teacher educators, and nine secondary and collegiate supervisors/ administrators. Because the success of the Delphi Technique relies upon the use of informed opinion, random selection was not considered when selecting the Delphi participants. However, demographics and gender were taken into consideration when selecting the Delphi team. Each region of the ITEA was represented and four women were members on the team. The participants that were selected are considered to be the well informed leading authorities in their field by their colleagues, supervisors, and peers. Criteria used in selecting the participants was based on their history of involvement in national and state professional associations representing technology education as well as their ability to formulate their thinking through writings and research.

University teacher educators of technology education and supervisors/administrators of technology education selected for the Delphi team averaged 23 years of experience in the field of industrial arts/technology education with an average of 32 publications relating to the field of industrial arts/technology education. Selection of the classroom teachers for the Delphi team was accomplished by an identification process which used two national surveys (one to state supervisors/administrators and one to university department heads of technology education) requesting the identification of the top three classroom teachers of technology education within their state. The following preliminary qualifying criteria was presented on the survey: (1) Currently teaching in a high quality secondary level technology education program; (2) Minimum of three years teaching experience as a secondary level classroom technology education teacher; (3) Prior experience in developing curriculum materials for technology education at the secondary level; (4) Creative and innovative thinkers in technology education; (5) Technically competent in their assigned teaching area; (6) Actively participates in state and national professional associations relating to technology education. The results of these surveys yielded 204 possible candidates for this Delphi study from which seven were selected.

Procedure

The first Delphi probe asked the panel to identify exhaustively the critical issues and problems for technology education using the four guiding questions created for the panelists. The issues and problems were divided into four parts: present issues, future issues, present problems, and future problems. The panel was provided a cover letter describing the process they were to follow plus definitions for the terms: critical issues, critical problems, present, and future. The second probe of the Delphi was designed to prioritize the identified issues and problems and begin the process of consensus. The third and fourth probe sought to improve the levels of consensus on the highest priority issues and problems. Descriptive statistics were used to analyze the data; critical issue and problem priorities were rank ordered; means, medians, and standard deviations were calculated for each item identified on the Delphi probes. Consensus on the prioritized critical issues and problems were determined by computing the interquartile range for each of the identified items. Each probe of the Delphi was completed by all of the participants thus yielding a 100% return rate.

Analysis of Findings

Delphi I

The first Delphi probe served as a beginning point for the study. Panel members identified a total of 580 items [143 Present Issues, 105 Future Issues, 198 Present Problems, 134 Future Problems] representing critical issues and problems for technology education. Based on the total number of identified issues and problems submitted key descriptors were identified from each entry and then grouped according to like classifications under each section of the study (Present Issues, Future Issues, Present Problems, and Future Problems). This procedure required the use of a review panel composed of two university professors and one graduate student from the technology education program area at the authors' university. Upon completion of the classification process there were 17 items in the Present Issues section, 21 items in the Future Issues section, 43 items in the Present Problems section, and 24 items in the Future Problems section. These classified items formed the basis for the critical problems and issues were evaluated further during the second and subsequent Delphi probes.

Delphi II

The purpose of the second Delphi probe was to determine the relative rank or priority of the items identified under each of the sections. Panel members were asked to select the top 15 critical issues or problems from the collapsed category list within each section. They were then asked to prioritize those top 15 issues or problems. Analysis of the responses involved a summation of each of the items along with consensus analysis within the specific sections. This initial classification of the top 15 critical issues and problems along with the analysis of consensus within the group (Interquartile Range [IQR]) are identified in Table 1. The high IQR scores indicate a wide variance of opinion in positioning the ranked items, this was not unusual for the first attempt of classifying a large list such as this.

Delphi III

The purpose of the third probe of the Delphi was to gain greater consensus of the top 15 critical issues and problems facing the technology education discipline. Based on the responses from probe 2, the panel members were asked to refer to their previous analysis and compare them with the identified top 15 issues and problems of the overall group. They were then asked to rank order the issues and problems again. Changes in the priority ranking from probe 2 to probe 3 can be observed in Table 2. The degree of consensus within the Delphi panel group improved, see IQR on Table 1 and IQR on probe 3 of Table 2. However, there were major changes in the prioritization of the critical issues and problems within each of the sections (Present Issues, Future Issues, Present Problems, Future Problems).

Delphi IV

The consensus process was refined further during the fourth probe of the Delphi. Panel members were asked again to examine their previous responses with regards to the overall group responses of the critical issues and problems and to make a final judgment as to their priority of importance relevant to technology education. Based on these evaluations, greater consensus was achieved within the group as evidenced by lower interquartile range scores (see comparison of probe 3 vs. probe 4 IQR scores in Table 2). The rank order of the critical issues and problems was maintained in most instances throughout the four sections of the Delphi probe (see table 2).

Table 1
Results of Delphi Probe 2

Present Issues

Rank	Priority Statement	Mean	SD	IQR	Mdn	
1.	Curriculum development approaches for Tech. Ed.		3.4	2.85	3.00	3.0
2.	Interdisciplinary approaches to teaching Tech. Ed.	5.2	3.22	3.50	5.0	
3.	Identity of the knowledge base of Tech. Ed.	5.2	4.78	5.00	4.0	
4.	Recruitment of students and teachers in Tech. Ed.	5.3	3.49	5.50	4.0	
5.	Adequate funding sources for Tech. Ed.		5.9	3.16	5.00	7.0
6.	Difficulty of changing from Industrial Arts to Tech. Ed.	6.2	4.58	6.50	5.0	
7.	Revisions and developments in teacher Education for Tech. Ed.	7.3	3.43	6.00	7.0	
8.	Methodology strategies for teaching Tech. Ed.	9.5	3.69	6.00	9.0	
9.	Certification options and strategies for Tech. Ed.	9.5	3.78	6.50	10.0	
10.	Tech. Ed.'s affiliation with Voc. Ed.	10.4	4.23	8.50	11.0	
11.	Clear research agenda for Tech. Ed.	10.6	3.65	6.00	11.0	
12.	Leadership (or lack of) within the Tech. Ed. profession	10.8	4.24	7.00	11.0	
13.	Technological literacy concerns for Tech. Ed.	10.8	4.38	7.00	12.0	
14.	Professional association impact on the Tech. Ed. discipline	12.3	2.78	3.50	13.0	
15.	Program closings and eliminations in Tech. Ed.	12.4	4.26	6.00	14.0	
16.	Number of females in Tech. Ed.	12.7	3.60	5.00	14.0	

Future Issues

Rank	Priority Statement	Mean	SD	IQR	Mdn
1.	Curriculum development paradigms for Tech. Ed.	5.1	4.71	8.50	3.0
2.	Knowledge base identification for Tech. Ed.	6.1	4.98	9.00	5.0
3.	Business, industry and political support for Tech. Ed.	6.2	4.75	7.00	6.0
4.	Interdisciplinary approaches for Tech. Ed.	6.4	4.53	7.50	5.0
5.	Positioning of Tech. Ed. in the school program	7.0	4.95	8.50	5.0
6.	Funding of Tech. Ed.	8.4	4.38	7.00	9.0
7.	Defining measurable outcomes for Tech. Ed. students	8.6	4.68	8.50	10.0
8.	Alternative vs traditional certification designs for TE	9.6	5.24	11.0	10.0
9.	Leadership directions and training for Tech. Ed.	10.4	4.37	8.50	10.0
10.	Conversion validity from Industrial Arts to Tech. Ed.	10.8	5.15	9.50	12.0
11.	Elementary option/emphasis in Tech. Ed.	11.2	4.35	7.50	12.0
12.	Voc. Ed. influences & relationship with Tech. Ed.	11.4	4.64	7.50	12.0
13.	Technological literacy and the role of Tech. Ed.	11.6	4.50	7.00	13.0
14.	Research agenda for Tech. Ed.	11.7	3.71	7.50	12.0
15.	Methodologies for teaching Tech. Ed.	11.7	3.84	6.50	12.0

Table 1 (cont.)
Results of Delphi Probe 2

Present Problems

Rank	Priority Statement	Mean	SD	IQR	Mdn	
1.	Inadequate marketing and public relations of Tech. Ed.	3.8	3.92	4.75	2.0	
2.	Inadequate financial support for Tech. Ed.	7.8	5.21	10.5	6.0	
3.	Lack of consensus of curriculum content for Tech. Ed.	9.0	5.21	9.50	10.0	
4.	Shortage of Tech. Ed. teachers	9.0	5.44	11.25	8.0	
5.	Teachers resistance to changes within Tech. Ed.	9.8	5.28	11.75	11.0	
6.	Inadequate methodological training/inservicing for Tech. Ed.	9.9	6.02	12.0	11.0	
7.	Inadequate/inappropriate Tech. Ed. teacher preparation	10.2	6.22	13.75	12.5	
8.	Declining enrollments in Tech. Ed. courses	11.1	5.88	11.75	16.0	
9.	Inadequate/ineffective leadership within Tech. Ed.	11.2	5.41	10.5	13.0	
10.	Deficient knowledge base for Tech. Ed.		11.3	5.41	10.75	16.0
11.	High schl graduation requirements restrictions on TE	11.5	5.89	11.0	15.5	
12.	Insufficient research base for Tech. Ed.	11.7	4.75	8.50	14.0	
13.	Inaccurate understanding & support of Tech. Ed. by administrators & counselors		12.0	4.35	7.75	12.5
14.	Slow transition and retraining of teachers to Tech. Ed.	12.0	4.35	7.75	12.5	
15.	Insufficient business, industry and parental support for Tech. Ed.	12.0	4.68	9.75	15.5	
16.	Title change without content change in Tech. Ed.	12.9	4.47	5.00	16.0	

Future Problems

Rank	Priority Statement	Mean	SD	IQR	Mdn	
1.	Insufficient quantities of Tech. Ed. teachers and elimination of teacher education programs in Tech. Ed..	3.4	3.73	3.50	1.0	
2.	Loss of Tech. Ed. identity, absorbed within other discipline	5.9	5.34	6.00	4.0	
3.	Poor and/or inadequate public relations for Tech. Ed.	7.6	4.08	6.00	8.0	
4.	Insufficient funding of Tech. Ed. programs	8.0	5.34	6.00	4.0	
5.	Non-unified curriculum for Tech. Ed.	8.3	4.94	9.00	8.0	
6.	Inadequate involvement of Tech. Ed. personnel in educational reform issues	8.6	4.14	6.50	8.0	
7.	General populous ignorant regarding technology and the discipline of Tech. Ed.	8.8	4.62	7.00	9.0	
8.	Elimination of Tech. Ed. programs	9.3	5.99	13.0	8.0	
9.	Inadequate business & industry support of Tech. Ed.	9.3	4.62	7.50	9.0	
10.	Inadequate leadership/leadership training for Tech. Ed.	10.0	5.03	10.5	10.0	
11.	Inadequate research base for Tech. Ed.	10.1	4.93	10.0	11.0	
12.	HS graduation requirements reduce opportunities for Tech.Ed. courses		10.2	4.34	9.00	9.0
13.	Inferior in-service training for Tech. Ed.		10.7	4.62	9.00	12.0
14.	Inappropriate certification procedures for Tech. Ed.		11.6	4.41	7.50	13.0
15.	Inadequate knowledge base for Tech. Ed.	12.0	4.98	7.00	15.0	

Discussion

Research Questions

The purpose of this research was to determine the present and future critical issues and problems facing the technology education field. Each of the four research questions were addressed and resulted in the identificaion of the top 15 critical issues and problems confronting the technology education discipline (see Table 3). The Delphi team members that identified these criteria of critical issues and problems were in overall agreement as to their character and rank order of importance. The interquartile range found extremely low variability for all issues and problems that were addressed in this research. Only 12 issues and problems indicated even a slight difference in consensus (IQR = 0.75-1.75) with seven of these with an IQR of less than one. Based upon these identified critical issues and problems one may now more accurately design a path to respond to these serious concerns and problems in technology education.

Trend Extrapolation

With the identification of the critical problems and issues in technology education several trends surfaced. In an examination of the top five (5) criteria within the issues and problems sections of this research, three (3) issues-/problems were identified multiple times. The most prominent criterion (identified within the top five critical issues and problems in all four sections) was the aspect of curriculum development concerns. Curriculum development approaches, curriculum development paradigms, lack of consensus of curriculum content, and non-unified curriculum were identified in each of the research sections respectively. This indication of curriculum concerns within the top five issues and problems sections was evidence of the strong need to design technology education curriculum that addresses a comprehensive approach to curriculum development. Although recent publications have identified a curriculum framework for technology education (Savage and Sterry, 1991) that have provided an overall orientation for the curriculum, there was an identified need to develop this effort further and to establish a unified curriculum that would serve as a standard.

The second criterion that was identified multiple times within the top five (5) critical issues and problems for technology education was the aspect of knowledge base concerns. The identity of the knowledge base for technology education was indicated in both the present and future issues sections ranking number 1 and 3 respectively (see Table 3). The need to establish a formal knowledge base was viewed as foundational to the future of technology education. A formal knowledge base would help in establishing needed precedents for future development within the field. The final criteria that was identified more than once in the top five (5) critical issues and problems sections was the concept of interdisciplinary approaches to the delivery of the technology education content. Interdisciplinary approaches to teaching technology education was selected as number 3 and 4 within the present issues and future issues section of this research. The need to integrate technology education with other disciplines was viewed as an essential element to the success of the field. The overlap of the descriptive issues and problem statements should be viewed as significant to developmental efforts in technology education however, caution should be exercised in placing priority to these particular issues and problems.

The 1990-95 Professional Improvement Plan published by the ITEA (1990) stated that the primary mission of the association was to advance technological literacy. The association presented six major goals designed to aid in the achievement of the overall mission. They are:

1. Provide a philosophical foundation for the study of technology that emphasizes technological literacy.
2. Provide teaching and learning systems for developing technological literacy.
3. Foster research to advance technological literacy.
4. Serve as the catalyst in establishing technology education as the primary discipline for the advancement of technological literacy.
5. Increase the number and quality of people teaching technology.
6. Create a consortium to advance technological literacy.

Of the six goals, numbers one through five were addressed specifically in the results from this research. This correlation was an indication that the efforts of the ITEA Professional Improvement Plan in working toward an appropriate direction to address pressing concerns and difficulties of technology education are on target. In addition to the Professional Improvement Plan, many other areas of need were identified in this research and should be further evaluated for possible actions.

Implications and Recommendations

The issues and problems that were identified in this research can serve as a foundational basis for future developmental efforts as well as evaluation criteria. By addressing the issues and problems, the leadership of technology education can proactively establish specific task force action groups to meet these challenges, strategically marshalling their use of human and physical resources.

Based on these findings the following recommendations are put forward:

1. Curriculum development should be given priority in further study and developmental efforts. The development of technology education curriculum with a central theme. High standards needs to be established at a national level and implemented at the state and local school levels.

Table 2
Results of Delphi Probe 3 and 4

Present Issues	**Probe 3**				
Priority Statement	Rank	Mean	SD	IQR	Mdn
Identity of the knowledge base of TE	1	3.4	2.34	3.75	2.5
Curriculum development approaches for TE	2	3.6	3.17	4.50	2.5
Interdisciplinary approaches to teaching TE	3	4.8	3.01	3.75	4.0
Revisions and developments in teacher education for TE	4	5.8	2.92	3.00	6.0
Difficulty of changing from Industrial Arts to TE	5	5.9	3.25	4.75	6.0
Recruitment of students and teachers in TE	6	6.1	3.50	7.00	4.5
Methodology strategies for teaching TE	7	7.4	3.57	5.00	8.0
Adequate funding sources for TE	8	7.5	3.62	4.75	6.5
Technological literacy concerns for TE	9	9.5	3.51	5.75	9.5
Clear research agenda for TE	10	10.2	4.08	6.75	11.0
Certification options and strategies for TE	11	10.5	3.14	3.75	10.0
Program closings and eliminations in TE	12	10.8	4.59	6.25	13.0
Leadership (or lack of) within the TE profession	13	11.2	3.33	5.50	11.5
Professional association impact on the TE discipline	14	12.2	3.35	5.00	13.0
TE's affiliation with Vocational Education	15	12.4	2.88	4.00	13.0

Table 2 (cont.)
Results of Delphi Probe 3 and 4

Future Issues	**Probe 3**				
Priority Statement	Rank	Mean	SD	IQR	Mdn
Curriculum development paradigms for TE	1	4.2	3.92	7.00	2.0
Positioning of TE in the school program	2	4.4	2.90	4.50	4.0
Knowledge base identification for TE	3	5.04	3.72	4.75	4.0
Interdisciplinary approaches for TE	4	5.08	3.61	3.75	4.5
Business & industry and political support for TE	5	5.4	3.98	6.75	4.5
Redefining the teacher education structure for TE	6	7.7	3.73	4.00	6.5
Funding of TE	7	7.9	4.09	6.75	7.0
Defining measurable outcomes for TE students	8	8.0	3.88	6.75	8.0
Leadership directions and training for TE	9	9.0	4.04	5.00	10.0
Elementary option/emphasis in TE	10	9.2	4.37	7.50	9.5
Methodologies for teaching TE	11	10.4	3.48	5.50	10.5
Technological literacy and the role of TE	12	10.5	3.48	6.00	11.5
Research agenda for TE	13	10.7	3.65	5.75	10.5
Alternative vs. traditional certification designs for TE	14	11.9	3.69	3.75	13.0
Conversion validity from Industrial Arts to TE	15	12.1	3.39	6.00	13.5

Table 2 (cont.)
Results of Delphi Probe 3 and 4

Present Problems			**Probe 3**		
Priority Statement	Rank	Mean	SD	IQR	Mdn
Inadequate marketing and public relations of TE	1	4.5	3.91	6.75	3.5
Lack of consensus of curriculum content for TE	2	5.0	3.97	6.25	4.5
Inaccurate understanding and support of TE by administrators and counselors	3	6.0	2.81	4.00	6.0
Teachers resistance to changes within TE	4	6.1	3.45	4.25	6.0
Inadequate financial support for TE	5	6.7	4.66	9.50	6.0
High School graduation requirements restrictions on TE	6	7.8	4.69	9.75	7.5
Slow transition and retraining of teachers to TE	7	8.3	3.49	4.50	8.5
Inadequate/inappropriate TE teacher preparation	8	8.41	3.95	7.50	8.5
Shortage of TE teachers	9	8.45	3.98	7.25	8.5
Inadequate methodological training /inservicing for TE	10	8.6	4.17	7.00	10.0
Declining enrollments in TE courses	11	9.4	4.05	5.75	9.5
Deficient knowledge base for TE	12	9.4	4.24	6.50	10.0
Insufficient research base for TE	13	9.6	4.21	7.25	11.0
Title change without content change in TE	14	10.3	3.82	6.00	10.5
Inadequate/ineffective leadership within TE	15	10.7	4.09	5.75	11.5

Table 2 (cont.)
Results of Delphi Probe 3 and 4

Future Problems			**Probe 3**		
Priority Statement	Rank	Mean	SD	IQR	Mdn
Insufficient quantities of TE teachers and the elimination of teacher education programs in TE	1	4.2	3.33	6.00	4.0
Loss of TE identity, absorbed within other disciplines	2	4.7	4.27	5.50	3.0
Poor and/or inadequate public relations for TE	3	5.3	3.58	6.50	4.0
General populous ignorance regarding technology and the discipline of TE	4	5.7	3.81	5.50	5.0
Non-unified curriculum for TE	5	6.3	3.84	7.00	5.5
Inadequate involvement of TE personnel in education reform issues	6	6.5	3.74	6.75	6.0
Insufficient funding of TE programs	7	7.2	3.71	4.00	6.0
Elimination of TE programs	8	8.1	4.55	8.75	9.0
High school graduation requirements reduce opportunities for TE courses	9	8.6	3.64	5.75	9.0
Inadequate business & industry support of TE	10	9.0	3.86	6.75	9.0
Inadequate research base for TE	11	9.5	3.33	6.75	9.5
Inadequate knowledge base for TE	12	10.6	3.76	5.00	12.0
Inadequate leadership and leadership training for TE	13	10.8	3.36	4.75	11.0
Inferior in-service training for TE	14	11.3	3.13	4.75	12.0
Inappropriate certification procedures for TE	15	11.6	3.00	3.50	12.5

Table 3
Final Results of Delphi on Critical Issues and Problems in TE

Present Issues

Rank	Priority Statement
1	Identity of the knowledge base of TE
2	Curriculum development approaches for TE
3	Interdisciplinary approaches to teaching TE
4	Revisions and developments in teacher education for TE
5	Difficulty of changing from Industrial Arts to TE
6	Recruitment of students and teachers in TE
7	Methodology strategies for teaching TE
8	Adequate funding sources for TE
9	Technological literacy concerns for TE
10	Clear research agenda for TE
11	Certification options and strategies for TE
12	Leadership (or lack of) within the TE profession
13	Program closings and eliminations in TE
14	Professional association impact on the TE discipline
15	TE's affiliation with Vocational Education

Future Issues

Rank	Priority Statement
1	Curriculum development paradigms for TE
2	Positioning of TE in the school program
3	Knowledge base identification for TE
4	Interdisciplinary approaches for TE
5	Business & industry and political support for TE
6	Redefining the teacher education structure for TE
7	Funding of TE
8	Defining measurable outcomes for TE students
9	Leadership directions and training for TE
10	Elementary option/emphasis in TE
11	Methodologies for teaching TE
12	Technological literacy and the role of TE
13	Research agenda for TE
14	Alternative vs. traditional certification designs for TE
15	Conversion validity from Industrial Arts to TE

Present Problems
Final Results of Delphi on Critical Issues and Problems in TE

Rank	Priority Statement
1	Inadequate marketing and public relations of TE

2	Lack of consensus of curriculum content for TE
3	Teachers resistance to changes within TE
4	Inaccurate understanding and support of TE by administrators and counselors
5	Inadequate financial support for TE
6	High School graduation requirements restrictions on TE
7	Slow transition and retraining of teachers to TE
8	Shortage of TE teachers
9	Inadequate/inappropriate TE teacher preparation
10	Declining enrollments in TE courses
11	Inadequate methodological training/inservicing for TE
12	Deficient knowledge base for TE
13	Insufficient research base for TE
14	Title change without content change in TE
15	Inadequate/ineffective leadership within TE

Future Problems

Rank	Priority Statement
1	Insufficient quantities of TE teachers and the elimination of teacher education programs in TE
2	Loss of TE identity, absorbed within other disciplines
3	Poor and/or inadequate public relations for TE
4	Non-unified curriculum for TE
5	General populous ignorant regarding technology and discipline of TE
6	Inadequate involvement of TE personnel in education reform issues
7	Elimination of TE programs
8	HS graduation requirements reduce opportunities for TE courses
9	Insufficient funding of TE programs
10	Inadequate business & industry support of TE
11	Inadequate research base for TE
12	Inadequate knowledge base for TE
13	Inadequate leadership and leadership training for TE
14	Inferior in-service training for TE
15	Inappropriate certification procedures for TE

2. Greater emphasis should be placed on the development of the knowledge base for the technology education field of study. The need to further identify the working theories and concepts of technology education must be addressed in order for the field to move forward as a legitimate academic discipline.
3. Serious efforts should be established and implemented to communicate the purpose and scope of technology education to decision makers and interested people groups. All levels of technology education teachers and ad-

ministrators need to be made aware of this serious issue/problem of public relations, positioning, and support gathering.

4. The Executive Director and the Board of Directors of the International Technology Education Association should evaluate the identified critical issues and problems and establish task force groups that will address the specific issues and problems.
5. Further research needs to be conducted to determine the views and perceptions of the rank and file teachers of technology education on perceived critical issues and problems for technology education.
6. Research of this type needs to be conducted periodically (every two to three years) to keep the technology education profession aware of needs and changing dynamics.

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Editorial

Under the Corporate Thumb: Troubles With Our MATE (Modular Approach to Technology Education)

Stephen Petrina[1]

In 1939, Ruth Streitz, a professor of education from The Ohio State University, wrote rather candidly of a proliferation of "canned units" in education. Units of work had been somehow interpreted to be glorified lesson packets of subject matter that could be bought and sold in somewhat of an unrestrained market. Given their relevance to contemporary problems with "modules" in technology education, her concerns are instructive:

> Blind following of dictates, regardless of their sources, caused many teachers to buy ready-made units of work. The result was a mail-order business with the buyer having no idea as to the purpose and function of his [*sic*] purchases in relation to his particular group. It was just as easy to order a unit. . . as it is to order a can of peas or a can of pineapple by a number which indicates content. The "canned unit" robbed the teacher and the pupils of the fun and intellectual stimulation which comes from real discovery and shared enterprises. (p. 258)

It may be worth pursuing a theory of periodicity to help to explain the recurrence of the "canned" product in education. During the 1960s, an annual 300 million dollar industry developed on teaching machine and programed learning products. Currently, but unique to the area of technology education, the same thing is happening with "modules," or more generally, the "modular approach to technology education" (MATE).

MATE connotes a self-contained (i.e., "everything" is there for the student) instructional *system* defined by programed learning theory, technological devices and equipment. Included are instructional systems ranging from desk top technology trainers and kits (e.g., LEGO-Logo, Principles of Technology, Fischertechnik trainers, etc.) to instructional spaces defined by architectural devices and equipment (e.g., Lab 2000, Synergistic Systems Labs, Pittsburg, KS Labs, etc.). MATE can be seen as an extension of benchtop trainers and

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electronic kits that are/were integral to electronics and power technology labs in industrial arts and vocational education. Also, MATE is a contemporary manifestation of teaching machine and programed learning theory of the 1930s-1960s.

According to Neden (1990), MATE is "designed around self-contained, two student-workstations that support self-directed, individualized instructional methodologies. Everything needed to complete an assigned task is included in the module area" (p. 28). Graves-Humphreys (1992) explained their "Modular Delivery System" (MDS) variation of MATE, and to the question "what is a module?" answered:

> A module is a defined lab space where students spend a majority of their classroom time completing the instructional activities. This space is equipped with all the materials, tools and equipment that students may require to complete the learning activities. The students follow a set of self-directed instructions that introduce concepts, reinforces the concept, provides hands-on activity demonstrating the concept and allows for validation and evaluation by the instructor (p. 4).

Graves-Humphreys suggests that students rotate from module to module every five days. Consistent with the mechanistic, systems metaphor that Graves-Humphreys suggested to be paramount in MATE, Lundquist, Dunekack & Falling (1991) of the Pittsburg, KS Labs, recommend that the students "cycle through" (p. 36).

This paper is intended to expose some of the troubles with our MATE, and inspire dialogue and debate on what seems to me, an entirely regressive trend in education. Four points will be argued. First, MATE represents more of a continuation of problematic industrial arts practices than a change. Second, MATE has been shaped with dated theory and problematic systems metaphors. Third, MATE may represent a divestiture of authority from institutions of teacher education and a conceding of that authority to product companies. And fourth, MATE represents a circumvention of curriculum theory and a surrendering of the burden of reponsibility for curriculum development to product companies.

First, MATE represents more of a continuation of, than a change from, the traditional industrial arts practice of organizing curriculum on equipment and devices. Certainly, the equipment on which MATEs are based reflect a departure from traditional "shop" technologies. For example, Graves-Humphreys's, Pittsburg, KS's, and Hearlihy's MATEs address technologies such as plastics, biotechnology, composites, computer circuitry, and video production. Herein may lie their real appeal to technology educators. And as Sanders (1990) observed, technology educators seem "enamored" with "new technologies, without any real consideration for how they fit into the curriculum. Many believe that a communication technology program with 'show and tell' units on fiber optics and lasers is automatically light years ahead. . ." (p. 133). Inasmuch as MATE offers different technologies than those institutionalized through industrial arts, curriculum organization is basically the same. As Sanders suggested, what is involved is often merely a replacement of equipment. Organization is based on new technologies; but still, narrowly constrained and defined by devices and equipment. A major change which accompanies MATE technologies, however, is the retrograde application of 1950s and 1960s programed theories of instruction and their explicit systems metaphors.

Second, MATE is a manifestation of dated learning theories, systems thinking, and their concomitant systems metaphors which reinforce ground-to-be-covered concepts of education. The "cycle through" process of MATE is the most obvious expression of systems thinking. Given a dominant technocratic rationality or tradition in technology education, it's not difficult to understand how programed instruction and systems thinking have come to be accepted as entirely amenable to MATE in the 1990s (Petrina, 1993, pp. 34-37). Programmed instruction and systems thinking are grounded in theories of behaviorism, cybernetics, training psychology, and instructional engineering and design (Joyce & Weil, 1980, sect. 3). These theories were given impetus and developed through work related to military and industrial training, educational practices related to control by behavioral objectives, and teaching machines of the 1930s through 1960s. Systems thinking is typically framed and articulated through models and metaphors defined by inputs, processes, outputs, and feedback loops (Romiszowski, 1981, pp. 7-35).

Systems models and metaphors are reflective of mechanistic assumptions in education. Systems metaphors reinforce values of technocratic rationality and social efficiency, and reflect "a conservative orientation [to schooling] that emphasized stability and certainty, and cast the student in a passive role to be manipulated according to uniform and predetermined behavioral outcomes" (Mazza, 1982, p. 24). Mechanistic assumptions underlie common educational metaphors such as factory, production, machine, and technical processes like "input-output" and "cycle through" (Apple, 1973; Clark, 1988; Westerhoff, 1987). As Eisner (1989) suggested, "the dominant image of schooling in America has been the factory and the dominant image of teaching and learning the assembly line. These images underestimate the complexities of teaching and neglect the difference between education and training" (p. 262). These mechanistic metaphors, according to Heshusius (1991), "narrowly conceive" and "trivialize life" (p. 38). For instance, Westerhoff (1987) suggested that as articulated through the factory metaphor:

> ...the curriculum is an assembly line, the student a valuable piece of raw material, the teacher a highly skilled technician, and the process one of gently molding each piece of valuable raw material in to the technician's

> predetermined design. Evidence of behaviorist thought are evident in this 'doing things to people' understanding of education. (p. 190)

Mechanistic metaphors have shaped thought in education since at least 1913, when Taylor's scientific management began to dominate educational discourse (Callahan, 1962, chap. 9) with a generally simultaneous emergence of Watson's and Thorndike's behavioral psychology.

In this light, there is a contradiction between product companies' claims that MATE is “the technology teaching system of the 21st century” (Hearlihy, 1992a, p. 1) and their reliance on decades-old learning theory and mechanistic metaphors rooted in the 1910s. One might also be prompted to question the validity of educators' claims of a “new departure” (Savage & Sterry, 1990b, p. 10), where the itinerary was partially developed by corporate MATEs, or “new paradigm” (Clark, 1989, p. 19) for technology education.

The relationship between systems metaphors, which frame MATE processes, and claims to a “discipline of technology” is one of mutual reinforcement. For example, Graves-Humphreys, Pittsburg, KS, and Hearlihy variations of MATE are predominantly used to access the codified bio-related, communication, production, and transportation disciplinary systems. These systems have been extensively promoted (e.g., DeVore, 1992; Hales & Snyder, 1982; Savage & Morris, 1985; Savage & Sterry, 1990a, 1990b; Wright, 1992), and widely accepted for state curriculum guides (Putnam, 1992). Tech-prep and other vocational organizations of curriculum are also reinforced through MATE. While certain groups stand to be enfranchised through this mutual reinforcement, traditional control over the ends of technology education is being challenged.

Third, MATE represents a divestiture of control and authority from a domain of technology teacher education, and a conceding of that authority to product companies and their operational context of corporate economics and politics. With product companies' traditional control over the means of technology education, and now with corporate MATE's comprehensive curricululum, authority and locus of control in establishing the ends of technology education may no longer be situated within a domain of teachers or teacher educators. In other words, the authority of teachers and teacher educators to select and fashion their own curriculum is being undermined.

It is ironic that the International Technology Education Association (ITEA) is sponsoring and promoting reforms that would replicate a MATE for teachers across the country (Wicklein, et. al., 1991). Through U.S. Department of Education funding, the ITEA's “Technology Education Demonstration Projects” has placed model demonstration technology education programs in various regions throughout the U.S. The Appalacian Region's programs are MATE centered, with “emphasis on the development of. . . technology modules” (DeVore, 1991, p. 9). With goals related to a “continued replication” of these programs, the demonstration project is aligned with various institutions of technology teacher preparation. Just how "continued replication" will occur is unclear, but there is precedence in corporate control and "canning" of educational products.

ITEA's relationships with corporate MATEs are, seemingly, intimate. The December, 1992 issue of *The Technology Teacher*, the ITEA's journal, ran a cover advertisement for Hearlihy's MATE. The cover photo of students in a classroom, with a Hearlihy manager posing as teacher, was contrived. This fact was not made known to *The Technology Teacher* readers. With authority granted through that cover ad, Hearlihy is defining what doing technology education *should* look like, and at the same time, advertising on the ITEA constituency's expense account. Possibly to capitalize on the academic authority of a specialized format of text, two MATE ads in that issue (and others) appeared, for all intents and purposes, as articles and *not* advertisements. Is the medium the message? The format and rhetorics of MATE advertising campaigns would alone supply ample content to support several critical lessons for a "corporate media and society" program.

My fourth point may be symptomatic of the previous point. MATE represents a circumvention of curriculum theory through equipment and a surrendering of the responsibility to address issues of curriculum to product companies. Indeed, Hearlihy's "thrilling high-tech curriculum," or "Modular Technology Education" (MTE), comes complete with lesson plans containing "instructor's notes, introduction, objectives, daily activities, conclusion, and tests & answer keys" (1992b, pp. 2m). A teacher's notebook which includes information on acquiring MATE funding, lab layouts, curriculum and equipment, an "outline of MTE testing and grading procedures. . . grade sheets, attendance & activity sheets & more" is also included (p. 3m). Marcraft (1992) offers a similarly comprehensive MATE which includes "combination courseware and hardware for school curriculum" (cover). Lundquist, Dunekack & Falling (1991) indicated that their Pittsburg, KS's MATE, "like the Lab 2000," can be "*purchased and installed as a package, complete with curriculum* [italics added], and has, in fact, been adopted by a large number of schools across the country" (p. 36). Similarly, Synergistic's (1991) MATE offers "the perfect learning environment" that provides "*the way to think*. . . the way to learn. . . *the way to teach* [italics added]" (p. 25). Presumably, the only thing missing from these MATEs, similar to the "canned units" of the 1930s and programed packages of the 1960s, is the student.

MATE, like textbooks, embodies the "selective tradition- someone's selection, someone's vision of legitimate knowledge and culture, one that in the process of enfranchising one group's cultural capital disenfranchises another's (Apple, 1992, p. 5). Apple also reminds us that behind the famous question about 'What knowledge is of most worth?' there lies another, even more contentious question, 'Whose knowledge is of most worth?" (p. 4).

There is reason to be concerned when the selective tradition is passed to the hands of corporate curriculum developers and centered within a locus of corporate control. As Streitz wrote of similar concerns in 1939:

> Not only has the sale of canned "units" been lucrative but some groups have controlled their content as well. Topics which might lead children to question certain political and economic practices prevalent in the adult world of today have been omitted: "unfairness to workers," "amassing fortunes at others' expense," "selling goods known to be inferior by taking advantage of others' ignorance," "extensive advertising of goods calling attention to certain supposed good qualities to obscure the harmful ones," "refusal to admit historical data that might lead children to question certain patriotic traditions," "consideration of minority groups with rights and privileges based not upon numbers or forces but upon the right of every individual to order his own life within the social structure." The reasons for omissions are too obvious to need elaboration. (pp. 258-259)

Likewise, corporate MATEs admit only selected views and ideologies on the social and cultural interaction with technology. Shaped by corporate values and market interests, corporate MATEs basically amount to "company" views of the technological world; and consequently, determine *what* and *whose* knowledge is legitimate. It would be difficult to find a corporate MATE that was sensitive to critiques which focused on gender, racial, military, labor, and class biases in modern technology; or, represented reconstructionist and reconceptualist views of the social order and social change. It would be surprising to find references to critiques grounded in the contemporary scholarship of the history, sociology, and philosophy of science or technology.

Like weather vanes, product companies may very well point in the direction that the wind is blowing in technology education classrooms. The nature of the popularity and the extent of MATE have not been well documented. Carter & Atkinson (1990) reported on a 1988 study of the use of the Principles of Technology/Energy Concepts, Inc. variety of MATE, but provided minimal descriptive data for the popularity reported.

The problematic condition of middle and high schools in the U.S. makes any criticism of something that anyone is "enamored with," including industrial arts projects, a sticky endeavor. However, in a context of a scarcity of resources and tax-payer dollars, the "revolution in [technology] education" that MATE companies are fueling, possibly through the Perkins Act of 1990, is disturbing (Synergistic, 1992, p. 33). With Synergistic's MATEs ranging from $2,495.00 to $12,980.00, Hearlihy's from $329.00 to $3,235.00, and other corporate MATEs within similar ranges, a critical look at MATE, if only from the standpoint of a concerned citizen, is warranted.

The notion, or panacea, of restructuring through new equipment and corporate curriculum, as opposed to pedagogical theory and sound practice, deserves critical assessment by educators. Otherwise, curriculum planning within technology education classrooms is liable to be nothing more, as Streitz suggested of the "canned unit" in 1939, than "shopping."

Reflecting on Schubert's (1986) comments, curriculum planning should rightfully be something more than shopping, in that what we are dealing with is "the fate of our children and youth, and what it means to turn their lives toward greater growth. . ." (p. 8). Certainly, Graves-Humphreys's, Marcraft's, Pittsburg, KS's, Synergistic's, or Hearlihy's MATE is no match for the practices of an imaginative and resourceful teacher with a grounding in contemporary educational theory, who can plan, design and redesign curriculum; and understands the difference between merely doing and a contextually rich educative experience. As Schrage (1990) wrote of the current "nintendo" mentality in education, which has much to do with technology educators' courtships with corporate MATEs: "The question *isn't*, 'what technologies do we need to best educate our children in the schools?' It's *'what is the real mission of the schools?*" [italics added] (p. F3).

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Credit should be given to teachers like Don Swanson at Northside Blogett Middle School in Corning, New York, who with his students, designs and redesigns his own technology education modules and curriculum. For draft reviews of this paper, the author would like to gratefully acknowledge the critical, yet complimentary comments of Ken Volk, Assistant Professor, East Carolina University; the always supportive comments of the late Donald Maley; and the genuinely constructive paper comments of the JTE editors.

Book Reviews

All Reviews by Dennis W. Cheek[1]

Cheek, Dennis W. (1992). *Thinking constructively about science, technology and society education*. State University of New York Press, $16.95 (paperback), 262 pp. (ISBN 0-7914-0940-6)

A synthesis of literature and thinking regarding STS education in light of curricular and instructional considerations. The second half of the book marshals a wealth of research in fields far removed from STS education; the author believes this research has utility in forging an appropriate and powerful conception of STS curriculum development and STS instruction.

Ferguson, Eugene S. (1992). *Engineering and the mind's eye.* The MIT Press, $24.95 (paperback), 241 pp. (ISBN 0-262-06147-3)

The author, a distinguished historian of technology at the University of Delaware, argues for a deemphasis of the role of the sciences in engineering practice. Building on a wealth of examples from the Renaissance to the present, Ferguson believes that the earlier emphasis in engineering education on engineering drawing resulted in better and more useful products. He comes full circle to argue that engineers need a working knowledge of the non-quantitative dimensions of their endeavors, and that for the sake of us all, engineering schools should incorporate these elements into their curriculum.

Inkster, Ian (1991). *Science and technology in history: An approach to industrial development*. Rutgers University Press, $50.00 (hardcover), 391 pp. (ISBN 0-8135-1680-3)

For many years, Inkster has probed the interactive dimensions of history, the social sciences, and industrial policy. This volume is a mature reflection on the interactions between science, technology and economic development from the eighteenth century to the present. Its focus is primarily on industrialization in the West, Japan, China, and India. The transfer of technology, technological diffusion, and the industrial revolution are discussed within the context of actual case studies of particular technologies.

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Israel, Paul (1992). *From machine shop to industrial laboratory: telegraphy and the changing context of American invention, 1830-1920*. The Johns Hopkins University Press, $38.50 (hardcover), 251 pp. (ISBN 0-8018-4379-0)

Using telegraphy as his focus, Israel documents how the rise of engineering science and scientific management transformed cooperative shop invention into the familiar industrial laboratories of the twentieth century. He explodes the myth that telegraphy was most strongly influenced by science, and shows how the mechanical shop tradition and its practices shaped the development of the telegraphy industry. Growing corporate control of inventions by the end of the period under study began to change the relationship and led to the electrical industries of telephony and electric lighting.

Lafollette, Marcel C., Jeffrey K. Stine, Eds. (1991). *Technology and choice: Readings fromTechnology and Culture*. University of Chicago Press, $16.95 (paperback), 341 pp. (ISBN 0-226-46777-5)

Technology and Culture is the official journal of the Society for the History of Technology (SHOT). This volume is a collection of fourteen readings from journal articles that appeared between 1966-1989, built around the general theme of choices that have been made regarding the use of various technologies. Key topics that are addressed within these articles include the regulation of private industry, social acceptance of commercial innovation, negative perceptions of technology, women shaping technology and being shaped by it, and cultural and artistic features of technology.

Marcus, Alan I. & Howard P. Segal (1989). *Technology in America: a brief history*. Harcourt, Brace, and Jovanovich, $12.00 (paperback), 380 pp. (ISBN 0-15-589762-4)

Perhaps the best, brief one-volume introduction to this subject in print. Each chapter concludes with a helpful bibliography for further reading. A multipage index makes referencing easy, and delightful photographs complement the text.

Mokyr, Joel (1990). *Twenty-five centuries of technological change: An historical survey*. Harwood Academic Publishers, $38.00 (paperback), 142 pp. (ISBN 3-7186-4936-5)

Within a very short compass, this book delivers what it promises, combining technological and economic history in a readable synthesis. The survey spans from classical antiquity to the early twentieth century. A concluding essay considers the “historical roots of technological creativity.”

Pacey, Arnold (1992). *The maze of ingenuity: Ideas and idealism in the development of technology*. 2nd ed. The MIT Press, $12.95 (paperback), 306 pp. (ISBN 0-262-66075-X)

From cathedrals to star wars, Pacey looks at the interactions of technologies and society over the last thousand years and uses that survey to argue for a more humane form of future technological development. Particular attention is paid to technological developments within Europe and North America since the period of the Industrial Revolution.

Petroski, Henry (1993). *The evolution of useful things: How everyday artifacts - from forks and pins to paper clips and zippers - came to be as they are*. Alfred A. Knopf, $25.00 (hardcover), 288 pp. (ISBN 0-679-41226-3)

Petroski, a civil engineer at Duke University, is the author of the well-known books *To Engineer is Human*, *Beyond Engineering*, and *The Pencil*. This last effort does in general, what *The Pencil* did with specificity; explain the ways in which social and technical factors combined have produced the amazing artifacts of our manufactured world. The driving force behind nearly all of these inventions and improvements is the failure of existing devices to live up to their promise. The book is a superb blend of history, design considerations, and the biographies of many of the unsung heroes of the technological world.

Rutherford, F. James & Andrew Ahlgren (1990). *Science for all Americans*. Oxford University Press, $9.95 (paperback), 246 pp. (ISBN 0-19-506771-1)

This is a slightly revised version of the AAAS Project 2061 document of the same name. The book is must reading for all who are concerned with basic questions concerning scientific literacy. A draft of the Project 2061 Benchmarks for Science Literacy is presently circulating within the educational community. It will outline curriculum standards in line with this document.

Schiffer, Michael Brian (1992). *Technological perspectives on behavioral change*. The University of Arizona Press, $29.95, 168 pp. (ISBN 0-8165-1195-0)

The first book of a new series on culture and technology, this is an anthropological view of technological change. The lens for analysis is the “artifact,” an object of study with which archaeologists and anthropologists are long familiar. Case studies in architecture, ceramics, and electronic technology, provide a basis for an anthropological understanding of how human behaviors have changed under technological influence.

Weber, Robert J. (1992). ***Forks, phonographs, and hot air balloons: A field guide to inventive thinking*. Oxford University Press, $25.00 (hardcover), 277 pp. (ISBN 0-19-506402-X)**.

In one of the more unusual books about technology, a psychologist probes questions like how the inventors of the sewing needle, the hammer, and the wheel found their ideas. He ends up finding what he believes are some basic heuristics (rules of thumb) that run across the many inventions that have arisen within history. His “archaeology of the mind” effort sheds light on both how we all problem solve and how we might better use our natural creativity.

Miscellany

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