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From the Editor

Since the “ink-on-paper” days of my first graphic arts course, the technology of publication has fascinated me. I had the good fortune of learning “hot type” by sweating over the composing stick to eek out a few sentences, as had been the custom for a full five centuries. I took enough interest to build a half-scale wooden printing press and trot about the countryside studying the surviving wooden presses in America.

Soon after its introduction, “cold type” (i.e. phototypesetting) rendered hot type obsolete. In 1980, when I assumed my current position of employment, I wasted no time in ridding my graphic communication lab of hot type. But within two years of taking possession of a “state-of-the-art” phototypesetter, generously donated by the Compugraphic Corporation, it too became obsolete. Macintosh and laser printers (low-cost “imagesetters”) brought WYSIWYG (what you see is what you get) typesetting to my lab for *a very small fraction* of the retail value of that phototypesetter. I'll not forget the day an entrepreneur from Texas packed it up and loaded it on a truck bound for his home state.

From its inception, the *Journal of Technology Education* has taken full advantage of electrostatic “typesetting.” Employing neither hot nor cold type, the JTE has benefitted from full electronic pagination and electrostatic imagesetting available in a university mainframe computing environment. Dodging the tedium of paste-up is singularly responsible for our ability to publish the JTE in-house at Virginia Tech. It simply would not have been feasible otherwise.

Now “electrostatic type” is giving way to total electronic publication. Should we call it “quasi-type” or “pseudo-type” or simply “e-type”? No one really knows what to call it. Unlike it's predecessors, there is no physical artifact in electronic publication. It is simply digital storage of text and images laying in wait for end-user retrieval, without the need for hard copy to *clutter* the process. It is ironic to think of hard copy as clutter, but we'd be kidding ourselves to think otherwise. Those who use e-mail regularly already see “snail mail” (the kind with a stamp on it) as vastly inferior. Can it be long before publications are perceived in the same vein? (It takes about a month longer to produce and distribute the hard copy of the JTE than it does the electronic version).

In any event, the electronic version of the JTE is my way of playing with the current technology. It fascinates me the same way hot type fascinated me two decades ago. With the support of the Scholarly Communications Project here at Virginia Tech, we are producing one of the very first electronic refereed journals. We have electronic subscribers around the world; more, in fact, than we have hard-copy subscribers. A number of university libraries are using the electronic version of the JTE to test the concept of electronic subscription and distribution. There are many questions to be answered in the academic community with regard to "e-journals" and the leading libraries in the world are currently wrestling with those questions. It's fun to be a part of the experiment.

We are nearing completion on an archival electronic version of the *entire Journal of Technology Education*, beginning with Volume 1, #1. The advantages of complete electronic versions of academic journals are obvious. Again, the JTE is perhaps the first refereed journal to boast a complete electronic archive. We are also experimenting with a Postscript version of the JTE. The Postscript version allows electronic subscribers to output hard copy that will *exceed* the quality of the printed version that regular subscribers receive! And the JTE is now available on an FTP server, providing virtually unlimited access to the *Journal* (see the "Electronic Access to the JTE" section at the end of the *Journal* for FTP instructions).

We plan to keep playing at this end, and hope you will do the same...

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Articles

Coping at the Crossroads: Societal and Educational Transformation in the United States

Glenn E. Baker
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As the nature of a workforce changes over time, one broadly-defined group of workers diminishes in numbers while another group increases in numbers. For example, during the period 1890-1910, the major proportion of the workforce in the United States shifted from agriculture to industrial production (U.S. Bureau of the Census, 1975). Figure 1 presents the concept. Relentless technological developments gave rise to new job classifications and to increased employment opportunities in industrial production. At the same time, technological developments diminished employment opportunities in another field, in this case, agriculture. Over the long term, then, one might expect that demand for groups of occupations will increase over time, but will be expected to decline when that employment sector is eclipsed by yet another employment sector, driven by a new technological wave.

The intersection of the two curves charting the demand for agricultural occupations and industrial occupations occurred during a time of rapid societal change, which was, in turn, a significant impetus for major educational change. Moreover, because these times of change have historical precedents, they may have a relatively high degree of predictability. Indeed, Toffler (1990) suggested that recent events are shaped by “distinct patterns . . . [and] identifiable forces” that once understood allow us to “cope strategically, rather than haphazardly . . .” (p. xvii).

To explore the hypothesis that educational ferment is a naturally occurring phenomena at the juncture of technological ages, selected economic transition points will be juxtaposed with developments in the evolving field of technology education. From this perspective, the recently-recognized shift in

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employment patterns from manufacturing-based employment to information-based employment has influenced the shift from an industrial materials content base to a technology systems base in contemporary technology education programs.

Figure 1. Labor force transition and educational reform.

Pace of Change

Zias (1976) argued that practitioners need a comprehensive historical understanding of an educational field in order to confront contemporary problems realistically. Without the underpinnings of a strong historical perspective, educators may confront the present with the naive belief that no previous situation has been characterized by such rapid and sweeping change. However, since the onset of the industrial revolution, rapid technological change has been characteristic rather than unique. Way (1964) noted that:

> Change has always been a part of the human condition. What is different now is the pace of change, and the prospect that it will come faster and faster, affecting every part of life including personal values, morality, and religion, which seem almost remote from technology . . . So swift is the acceleration, that trying to 'make sense' of change will become our basic industry. (p. 113)

It appears that Way's prediction has already been realized. Snyder's (1987) interpretation of the composition of the U.S. workforce places more than 50% of the labor force now as information workers. The task of making sense of change has become a basic requirement of everyday life.

Wave Theory as an Explanation of the Change Process

The explanation of social change and the prediction of likely future change through applications of wave theory is not new. Toffler (1970, 1980, 1990) has written extensively about the three great waves that have transformed human society: agricultural; industrial; and post-industrial, or information. In a contemporary analysis of economic activity, Van Duijn (1983) compared the economic wave cycle theories of Mensch, Jantsch and others. This seminal work condensed the thoughts of many theorists in many languages and emphasized the influence of technological innovation on economic and industrial growth and decline. Van Duijn cited Mensch, in particular, as depicting technological innovation as driving cyclical periods of increase and decline. Ayers (1990) identified five long economic cycles since the beginning of the industrial revolution, and concluded that "advances in technology, together with, and exhaustion of, certain natural resources, have combined to bring about a series of coordinated technological transformations that are correlated with waves of economic activity" (p. 3). Combining the agricultural, industrial, and information waves delineated by Toffler with the five economic cycles described by Ayers clearly identifies periods of unusual social stress. This analysis also provides a useful framework for reviewing the relationships of social stress and changes in education. The analysis also poses predicative implications.

Figure 2. Transformational waves and long economic cycles.

The First Long Cycle

According to Ayers (1990a), a cluster of inventions in Great Britain about 1775 made possible the development of the steam engine, wrought iron, and cotton textiles (Ayers, 1990 a; Kicklighter, 1968). These developments, coupled with a shift to coal as a major energy source and the construction of an inter-linked canal system, fueled the first long cycle. Power, manufacturing and transportation were the hub of the new technology which emerged.

Educational response. From this shift from agrarian to industrial economies, two societal stresses also developed, First, populations shifted to urban areas, and secondly, demands for trained industrial workers began to develop. From the initiation of industrial activity, changes in society created conflicting viewpoints on the proper education for changing circumstances. During the first cycle, the Calvinist ideals championed by Francke and the sense-realist approach favored by Rousseau exerted significant influence on education. The *Schools of Industry* which proliferated in Austria, Germany, and Britain sought to develop the habits of industry among the poor (Bennett, 1926). With the development of such practically-oriented programs, education was viewed as important for all individuals growing up in the society. Education was also viewed as a contributor to the solution of social problems.

Rousseau is credited with opening a new era in education by recognizing that “manual arts may be a means of mental training” (Bennett, 1926, p. 81). Rousseau believed that the education of children should be a natural, spontaneous affair catering to the natural curiosity of children. The concept of “learning by doing” has developed a rich educational tradition that flourished in the work of Pestalozzi, Fellenberg, and Froebel. These ideas all contributed to educational influences in the United States as this nation underwent similar shifts in economy and society.

The Second Long Cycle

The first and second long cycles together make up what is commonly referred to as the industrial revolution (Ayers, 1990a). The second cycle, which began in Britain about 1825, was stimulated by technological inventions and improvements that led to the railroad construction boom of 1838-1843 and the accompanying telegraph network. These two innovations created a faster, more efficient transportation system coupled with a new communication network. Together, these systems established an infrastructure which further expanded the opportunities for economic development. In the United States, the events were somewhat later, but very similar. Fulton applied steam to boats in 1838, the telegraph spanned the continent in 1861 and the historic "golden spike" connected the railway systems of the east and west in 1867.

Educational response. While workers in the first cycle of industrialization needed only minimal skills to perform their jobs, many second cycle workers were required to develop much higher levels of technical competence. By 1875, few U.S. students finished high school and fewer had employable skills despite a growing need for technically proficient workers. Society was expecting schools to prepare its youth, but the schools were based on a classical educational pattern. This societal impetus influenced the thoughts of Runkle at MIT, Woodward and Dewey (Bennett, 1926).

Other schools of applied science and engineering, which built on the "learning by doing" precepts of the first cycle, also appeared throughout Europe. A significant response in the United States was the Morrill Act of 1862, which established land-grant colleges for the study of agricultural and mechanical arts in each of the states (Bennett, 1926).

The Third Long Cycle

The third cycle, the second industrial revolution, began about 1870 (Ayers, 1990a). Major technological breakthroughs of this era included the development of steel, the widespread application of the internal combustion engine, the creation of networks to transmit electricity, and the evolution of a manufacturing system based upon mass production and interchangeable parts. In the third cycle as never before, much of the technological innovation was devoted to the development of consumer products and services: interurban trams, telephones, and household appliances.

Educational response. By the time of the 1920 census (U.S. Bureau of the Census, 1975), employees in the manufacturing sector outnumbered agricultural workers in the United States for the first time. The crossing of the employment curves, as in Figure 1, signalled the need for a change in educational direction. While the need for educational change was clear, the direction that the change should take was hotly contested. The social and education turmoil of this era is well documented (Barlow, 1976; Bennett, 1937; Glatthorn, 1987; Luetkemeyer, 1987). In highlighting some of the concerns of the day, Law (1982) observed that:

> In the last decade of the 19th century, marked by unrestricted capital speculation, violent clashes between labor and industry, social unrest and political turmoil, there was a mounting wave of criticism regarding the elitist posture of the public high school. In a period when private and

> public secondary schools combined served only 6.7% of the age group, and colleges 1.5% of theirs, the inherent failure of the public school system had become a burning issue. (p. 19)

During this period of social upheaval, the Smith-Hughes Act, which was passed in 1917, marked the beginning of federal funding for secondary vocational education in the public schools. Passage of the Smith-Hughes Act could only be accomplished through the formation of a remarkable coalition comprised of diverse special interest groups (Hillison, 1987). Bennett (1937) observed that the Smith-Hughes Act was likely the best compromise possible, given the turmoil of the time. Even critics of the Act, such as Law (1982), conceded that no other legitimate alternative seemed possible.

Innovations

The crises of this period were addressed by the promulgation of the seven cardinal principles which were adopted by the NEA and which formed the basis of the comprehensive schools of the next several decades (Kozak & Robb, 1991). These principles, when combined with the Smith-Hughes Act and the guidance movement, formed the educational structure that effectively launched a reformed educational approach to address the societal needs of the time. Included in these new reforms were industrial arts, as distinguished from manual training, manual arts, and vocational education -- especially as developed by Bonser and Mossman at the Speyer School of Columbia University (Bennett, 1937).

The Fourth Long Cycle

While the fourth long economic cycle did not have a clear starting or ending point, Ayers (1990b) located its origins in the depression of the 1930s and its end in the mid 1970s. The leading economic sectors in this cycle included the automobile, electrical and electronics, chemical, and aerospace industries. Ayers noted that, in spite of the array of technological developments, only television, semiconductors, and electronic computers were new technological innovations of this era.

Educational response. Glatthorn (1987) described four major approaches to curriculum development that were popular during the period, 1917 to 1974. The major societal strains involved in accommodating the shift to the industrial era were relatively well stabilized by the time of the passage of the Smith Hughes Act and the establishment of support for formal programs of vocational education in 1917. A relatively stable period followed in education until about 1940. Three identifiable curriculum orientations (developmental conformism, scholarly structuralism, and romantic radicalism) appeared in succession as the industrial age gave way to the service and information ages. Coincidentally, 1974 marked the shift to a new curriculum orientation, privatistic conservatism (Glatthorn, 1987), and the approximate transition point between Ayers' fourth and fifth cycles.

Bell (1973) identified 1956 as the date when number of white collar workers surpassed total employment of blue collar workers for the first time. Toffler (1980) also noted 1956 as the approximate beginning of the Third Wave. The educational impact of these transitions was eclipsed on October 4, 1957, when the U.S.S.R. successfully launched the first space vehicle into orbit around the earth.

The change in workforce demographics, coupled with the response to Sputnik, released a massive burst of school reform and curriculum innovation. Conant's (1959) work reemphasized the need for a comprehensive high school encompassing the arts, humanities, science, math, and vocations. Conant also stressed the need for high standards in the comprehensive high school. Cochran (1970) observed that the 1960s produced more change and modification in industrial arts programs that any previous decade. The Industrial Arts Curriculum Project, American Industry Project, and Orchestrated Systems Approach were some of the better known industrially-based curriculum projects of the era. Further, the study of technology, first proposed by Warner in the 1940s, received increased emphasis through the work of Olson and DeVore (Householder, 1979). Olson's (1973) concepts of interfaces stressed that a static curriculum was inappropriate. These concepts, combined with Maley's (1973) emphases on group synergy, technological development, and research helped provide a foundation for a systems approach where the individual interpreted factors in solving technical problems.

The Fifth Long Cycle

The long cycles described by Ayers (1990b) averaged approximately 50 years in length. They generally began with a cluster of innovations that occurred during the economic slowdown between cycles. The fourth long cycle concluded in the mid 1970s; the fifth long cycle is still evolving. But, as Ayers noted:

> It is now widely recognized, and correctly so, that 'high tech' was the leading sector of the 1980s. Within the present decade, or early in the next one, the computer and telecommunications sectors are almost certain to overtake the auto industry and its satellites as the 'locomotives' of the world economy. Already, computers and related automation equipment have become the dominant form of capital equipment, and software development and maintenance are becoming major sources of employment. (p. 127)

Ayers suggested that the computer chip revolution has yet to have significant impact upon manufacturing and that computer integrated manufacturing (CIM) will "almost certainly turn out to be one of the 'leading sectors' of the fifth technological transformation" (p. 128).

Educational response. Analysis of the educational change that occurred in previous long cycles could be addressed from the comfort of a historical point of view. However, as this essay is written at the transition between two long cycles, as defined by Ayers, and two technological waves as defined by Toffler, the analysis of the present is much more difficult, and the inference of the coincidence of the two wave cycle patterns suggests enormous impact. The early 1980s were characterized by numerous reports that suggested what "ought" to be done in various educational settings. Strickland (1985) noted the relationship between education and national security in the call for educational reform. In reviewing four prominent reports on education (*A Nation At Risk, Educating Americans for the Twenty-first Century, Actions for Excellence, and Making the Grade*) Strickland drew the parallel between the post-Sputnik reaction and the clamor for educational reform which characterized the 1980s.

Industrial arts responded to the realities of the new workforce expectations by pursuing a change to technology education. While many varieties of technology education are currently practiced and proposed, the common features of most programs include: (a) an emphasis on problem-solving capabilities; (b) an interdisciplinary approach that emphasizes alternatives and compromises, (c) the integration of context in an approach to recognize systemic functions, and (d) an assessment of the consequences of technological activities.

Summary of the Impact of Technological Transformations on the Workforce

A useful summary of the impact of technological transformations on the workforce is provided by data on labor force participation in the four sectors of the United States economy. For the period between 1860-1995, Liedtke (1990) reported that:

1. The agricultural workforce peaked in the late 1800s and had declined to less than 3% by 1980.
2. Industrial workers had three employment peaks in this period, around 1860, 1917, and the mid 1950s. However, since the peak in the 1950s, industrial sector employment has declined to less than 20% of the labor force.

3. Service workers averaged about 20% of the work force from 1860 through 1960. Since 1960, however, the proportion of service workers has risen dramatically.
4. Only the information sector of the work force has demonstrated consistent growth over the period. As of 1987, information workers held more than 50% of all jobs.

Combining the long cycle analysis by Ayers (1990a, 1990b), workforce demographics, and the history of industrial education leads to the conclusion that major philosophical and curricular stress points do indeed coincide with the wave cycles of technological transformation. As each wave of economic activity required different skills of its workforce, societal and educational forces attempted to reform to meet the perceived needs. Efforts at educational reform prior to the societal needs largely fell on deaf ears, regardless of the validity of thought.

Further, as the occupational requirements became more complex, the degree of educational ferment accompanying each transition point appeared to have increased. During the early waves of industrial enterprise, the educational response was generally limited to isolated activities of individual innovators. These resulted in such diverse offerings as the *Schools of Industry* and the Mechanics' Institute Movement.

However, dealing with educational change in later industrial waves became increasingly complex as diverse interest groups championed their own interests. The cauldron of educational controversy preceding the passing of the Smith-Hughes Act was clearly without precedent in the United States. Subsequent educational responses have perhaps been as frenzied from the point of view of curriculum development and legislation, but not as bitterly contested. For example, the educational innovation which followed Sputnik seemed to proceed from a collective national purpose. Coping with the age of the information worker has led to substantial reporting and substantial displacement of workers. The corollary, a cohesive reorganization of the whole educational focus, such as occurred in 1917 and 1958, appears to be lacking.

The major controversy seems to focus on educational retrenchment and the re-emphasis upon the traditional academic subjects. Historically, this sort of modification often follows a pattern in which retrenchment of one group eventually leads to a new solution promulgated by another group. For example, the content and emphasis of the baccalaureate degree changed markedly as land grant colleges provided new solutions to the need for practically-oriented programs of higher education. The answers to the problems which have precipitated the current educational reforms are still evolving and are clearly not yet complete.

Lessons from the Past and Implications for the Future

The analysis of historical cycles presents opportunities for addressing present and future educational needs. This analysis suggests a wide range of lessons from the past and offers provocative implications for future educational planning. These inferences and implications include the following:

1. Change in the composition of the workforce is a continual process driven largely by technological innovation.
2. The responses of education have generally been reactive in response to the forces of change, rather than proactive in anticipation of change.
3. The skills required of workers have consistently become more complex. Literacy is no longer an option. Increasing job complexity requires high-order thinking skills and problem solving capabilities in a world of local area networks (LANs), fax, and e- mail.
4. One constant in the evolution of technology education has been the need to demonstrate that the discipline has made a contribution to the economic well-being of the country. Times of retrenchment by traditional educators, who vastly outnumber technology educators, exacerbates this need.

Educators in every era have been convinced that there have never been times like these before. And while this is always true to some extent, perhaps only now has the rate of change reached the point where teaching only cognition (the exchange of information) is in question. Toffler (1990) observed that the information age does not need workers who are essentially interchangeable workers as in the industrial era, but rather individuals with diverse and continually evolving skills. Wright (1990) pointed out more specifically the need for developing students who are:

> Flexible, adaptive, life-long learners who can effectively work in groups. . . . that manual skill and detailed technical knowledge had only marginal value compared to problem solving and creative abilities; and that a broad understanding about technology provides a valuable base for consumer, citizenship and career activities. (p. 3)

Many reports and studies have repeated this call. The conceptual framework for technology education (Savage & Sterry, 1990) placed problem solving at the center of the curriculum development model. This is a significantly different approach than the model of industrial technology education (Hales and Snyder, 1980) which has guided the field in recent years.

In a more specific context, Zirbel (1991), in a needs assessment of the manufacturing engineering technologies, found that only two of the top seven rated competencies were directly related to engineering technologies -- and those two dealt with analyzing processes. The other competencies look familiar to those analyzing workplace trends:

1. Understand the importance of quality.
2. Display motivation, responsibility, and natural curiosity.
3. Communicate clearly and concisely.
4. Work effectively as part of a team.
5. Demonstrate a basic working knowledge of personal computers.

Carnevale, Gainer and Meltzer (1990), in the report of a major study which seems destined to become a classic, proposed seven essential groups of workplace competencies:

1. Knowing how to learn.
2. Reading, writing, and computation.
3. Oral communication skills: listening and speaking.
4. Creative thinking and problem solving.
5. Self-esteem, goal setting, motivation and decision making.
6. Interpersonal skills, negotiation, and team work.
7. Organizational effectiveness and leadership.

What is interesting about the new list of "oughts" is the convergence of various occupational needs with current educational priorities. The common focus is on problem solving, communicating and team work, all in more technological and complex settings.

Conclusions

Finding educational direction at the crossroads of technological eras is clearly no easy task. Scores of educational reports of the 1980s attest to this difficulty. However, each of the cycles which have been examined in this essay eventually evolved its own unique solution. Based on historic precedent, the following conclusions appear likely:

1. Education reform may be two cycles behind changing social and economic circumstances.
2. Education should be less concerned with courses and subjects as static elements and more concerned with the identification of the components of "basic education."
3. Change will occur more rapidly. Change may now be occurring at a pace that makes it difficult to even observe the transition points.

Ayers (1990b) pointed out the difficulty in precisely defining the transition points in the last two waves in a way which highlights this problem.

4. The new "basic" should not be based on a static curriculum. Rather, it should have a proactive ability to anticipate. The new "basic" must diminish barriers between subjects of study (knowledge) and seek to integrate knowledges and experiences to make them more meaningful. While technology education is not construed to be "vocational," it must relate to a competent workforce as a part of basic education required by all prior to the acquisition of job skills.
5. The nation, to remain competitive in a global society and economy, cannot depend on government bureaucracy to lead the change. Historically, all major reformations were preceded by periods of diversity and experimentation. If we face a future of continued rapid change, school quality could become more dependent upon new ideas and experimentation. Conformity and stability of context are not conducive to coping with rapid change. The future will depend upon individual schools and educators who are empowered to innovate rather than conform.
6. Accreditation guidelines and procedures must also change from an emphasis upon meeting standards to an emphasis upon successful motivation and learning.

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A Comparison of Principles of Technology and High School Physics Student Achievement Using a Principles of Technology Achievement Test

John Dugger and David Johnson

Society has traditionally taken the position that education is a primary means of achieving national goals. Unfortunately, we have never collectively agreed upon "what kind" of education is needed--general or vocational. The present K-12 public educational system in the United States is comprised of general and vocational education tracts.

Historically, one of the goals of vocational education has been to provide entry-level job skills. In contrast, general education, as the title implies, has attempted to equip students for living or for further education. In preparing students to enter the workforce, vocational education can provide an opportunity to obtain hands-on experiences with many of the theoretical concepts presented within the general education classes. Many secondary education students, however, never take vocational courses because they do not view them as relevant to college preparation (Meier, 1991). Conversely, many vocational education students are not taught the theoretical mathematics and science concepts that are needed to cope with a rapidly changing society.

Vocational education has been considered a separate discipline within the broad context of education and has been in continuous competition with general education for students and resources. Vocational education has been concerned with providing people with gainful employment after graduation. A "Blue Collar" affiliation is considered undesirable by those students wanting to attend college or obtain further education. The unfortunate outcome is that the average high school graduate is "nonfunctional" in our modern society (Cummins, 1989).

If education is designed to help the individual attain self- fulfillment in a technologically complex, work-oriented society, then education must be a synthesis of both general and vocational education. Anything less jeopardizes the individual's opportunity for self-fulfillment.

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A knowledge of how to integrate mathematics and science into technology is a necessity in today's society and those individuals who cannot function at that level will effectively be disenfranchised from participating fully in our national life. In fact, those citizens not educated in science will be unable to make informed decisions regarding such issues as nuclear energy, radiation, and pollution (The National Commission on Excellence in Education, 1983).

Many Iowa high school vocational education programs provide minimal exposure to anything beyond basic principles of mathematics and science. Consequently, students choosing the vocational rather than general education track run the risk of not obtaining an adequate mathematics and science background. They will be incapable of comprehending the technologically complex society of the 1990s and beyond. This common occurrence might be avoided by establishing a stronger relationship between general and vocational education programs at the high school level.

Newly approved federal legislation has been designed to improve existing vocational programs by strengthening the linkage with general education in the areas of mathematics and science. The Carl D. Perkins Acts of 1984 provided considerable emphasis on the importance of mathematics and science principles within vocational education programs, and was seen as a positive step toward better academic relationships between vocational and general education programs. The newly approved Carl D. Perkins Vocational and Applied Technology Education Act of 1990 became law on September 25, 1990. In signing this law, President George Bush authorized $1.6 billion in federal funds to improve:

> ...educational programs leading to academic and occupational skills competencies needed to work in a technologically advanced society (Section 2).

The Perkins Act of 1990 holds considerable opportunity for both vocational and general education in building and reinforcing what Erekson and Herschbach (1991) refer to as "strategic partnerships." These collaborative efforts can be instrumental in providing educational programs which integrate vocational and general education concepts, making them relevant in today's technological society.

One promising development designed to infuse general education mathematics and science concepts into the high school vocational education curriculum is entitled Principles of Technology (PT). This program was developed by the Center for Occupational Research and Development (CORD) in Waco, Texas in the mid 1980s to supplement vocational offerings in secondary programs.

Principles of Technology--Purposes and Description

The PT program is a two-year, high school course in applied physics, made up of fourteen units, each investigating an important principle. The content for each module is specified in Figure 1. Each of the individual fourteen concept modules is studied within the context of electrical, mechanical, fluid and thermal energy systems.

FIRST YEAR CONCEPTS	Force Work Rate Resistance Energy Power Force Transformation
SECOND YEAR CONCEPTS	Momentum Waves and vibration Energy conversions Transducers Radiation Optical systems Time constraints

Figure 1. Principles of Technology Concepts

The physics concepts are taught within a laboratory setting, which allows students to obtain both theory and hands-on application of each principle. The students enrolled in the PT program are from the vocational education track and not typically enrolled in physics courses. For the most part, PT courses in Iowa are taught by industrial technology teachers. In Iowa, industrial technology education is included under the vocational umbrella. The primary benefit of the PT curriculum is the emphasis on application skills using mathematics and science concepts.

Purpose of the Study

Since the State of Iowa had invested heavily in the Principles of Technology program through vocational education, it was important to complete a summative evaluation of this program. The amount of achievement gained by students based on exposure to the first year Principles of Technology program was of interest to the State of Iowa and program developers. Since the program was designed to cover basic physics concepts, it was also important to compare the gain with any gain that was due to exposure to a basic high school physics class. Accordingly, the purpose of this study was to compare student achievement regarding certain basic physics concepts between students who had completed first year Principles of Technology and students who had completed high school Physics.

Method of Study

The methodology employed in this study included population and sampling procedures, instrument development procedures, data collection, and data analysis. A pre-test post-test control design was utilized with two treatment groups. The following figure depicts this design.

Principles of Technology	T1	X1	T2
Physics	T1	X2	T2
Control	T1		T2

T1 = Pre-
T2 = Post-
X1 = PT Treatment
X2 = Physics Treatment

Figure 2. Research Design Model

Population and Sample

The population for this study was all secondary vocational programs in Iowa where Principles of Technology was offered. With more than 50 sites of implementation, Iowa was a good location for the study. The sites were at various stages of implementation. Sixteen sites had offered the program for two years or more. In order to obtain a better estimate of the effectiveness of the program, only sites that had offered the program for at least two years were utilized. Therefore, the sample included these 16 Iowa sites.

Of these sites, 14 programs were being taught by industrial technology education teachers who had participated in one two-week workshop to prepare for teaching the Principles of Technology. The remaining two sites were taught by certified Iowa high school physics teachers. During the data collection for the first year programs, one program taught by an industrial technology education teacher failed to complete the study. Therefore, the sample for this study consisted of 15 Iowa high schools where Principles of Technology and physics were taught as a part of the regular curriculum.

Instrument Development

The procedure involved the generation of a test item bank covering all objectives for the first seven units or the first year of Principles of Technology. Conversations with many people involved with the course suggested that during the first year only six units could be covered rather than seven. Therefore, the questions on the instrument were limited to only those first six units. The item bank was generated by participants and project staff at Iowa State University during the summer Principles of Technology workshops. Multiple items for each objective were generated. These items were then examined by the project staff and modified to improve clarity and assure good testing procedure. Five secondary physics teachers and one community college physics instructor were hired to revise items as necessary to standardize terminology that may differ in Principles of Technology materials and Iowa high school physics materials. It was determined that a number of terms differed and where differences existed, both the Principles of Technology term and the term found in typical physics textbooks or materials were used.

These items were then formed into 40 question unit tests and administered at the 15 sites. An analysis of the six unit test yielded degree of difficulty scores for each item and the degree to which each item correlated with the total unit score. This information was utilized in the selection of items to be included in the overall first year Principles of Technology instrument. This instrument consisted of 120 questions and covered each of the six units.

Data Collection

The data collection phase involved two steps. The first step was the administration of the pre-test, a form of the 120 question instrument developed in the previous phase. The second step was the administration of a post-test at the end of the academic year at each of the 15 sites.

The two treatment groups included students enrolled in a Principles of Technology first year class and students enrolled in a high school physics class at each of the 15 sites. The control group consisted of students who were enrolled in neither the Principles of Technology nor physics, but had a similar male-female ratio and similar achievement on the Iowa Test of Educational Development (I.T.E.D.) as the students enrolled in the Principles of Technology class.

The pre-test data were collected during the first two weeks of September. The post-test data were collected during the first two weeks of May. The relatively early post-test data collection was necessary since many seniors complete their coursework during this time.

Data Analysis

The data analysis procedures included both an item analysis of the pre-test and post-test results along with a one-way analysis of variance of the treatments and control groups. The results of these analyses are reported in the next section.

Results

The focus of this section is on the achievement measures for both the pre-tests and post-tests for all three groups. Pre-test and post-test scores are listed for all groups in Tables 1 and 2.

Table 1
Differences Between Pre- and Post-test Scores For Treatment and Control Groups

	Pretest		Post-test		*t*
	Mean (SD)	*n*	Mean (SD)	*n*	
PT	47.80 (11.30)	257	80.14 (17.16)	139	20.0*
Physics	55.07 (12.07)	275	65.77 (16.33)	136	9.3*
Control	37.78 (8.62)	135	36.45 (10.94)	83	0.942

*p<.01

The higher mean pre-test by the physics students suggests that science achievement may be initially higher in this group.

The number of subjects taking the post-test was reduced significantly when compared to the pre-test numbers. Follow-up calls to the sites indicated that many seniors were not available during post-test administration. It was discovered that many Iowa schools release their seniors up to three weeks prior to the end of the semester. Normal class attrition was also a factor.

The Principles of Technology students scored significantly higher than the other two groups on the first year post-test. Although the physics group displayed a gain, it was not nearly as great as the gain for the PT students. Pre-test, post-test, and levels of significance for each of the three groups are listed. A significant increase in student achievement was one outcome of exposure to the first six Principles of Technology units.

Implications

Based on Principles of Technology pre- and post-test results, it appears that exposure to the first six units of the Principles of Technology results in significant student achievement gains regarding basic physics principles. It appears reasonable to conclude that the methodologies employed by this very structured program are appropriate for the content covered. If one assumes that the content is necessary and useful for the majority of the students, then most school districts should seriously consider the Principles of Technology as an offering for a wide range of students. This is consistent with the claim that PT was designed for students that fall between the 25th and 75th percentiles.

Although never intended to replace Physics, the Principles of Technology first year course does a significantly better job in increasing student achievement regarding basic physics concepts as defined by the Principles of Technology program. One must exercise caution in drawing inferences regarding the two programs since physics also is responsible for covering higher level concepts that are not considered basic and may be considered non-intuitive.

One may conclude that the Principles of Technology does an excellent job in addressing the objectives as listed at the beginning of each unit. The test questions used for the pre- and post-test were drawn from these objectives.

Several questions remain however:

1. How will students who have completed Principles of Technology perform on standardized physics achievement tests?
2. If Principles of Technology is taught entirely by certified physics teachers, will the student achievement scores increase or decrease?
3. Can the repetition of subsystems (mechanical, fluid, electrical, and thermal) be useful when organizing high school physics content?

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Post Hoc Analysis of Test Items Written by Technology Education Teachers

W. J. Haynie, III

Technology education teachers frequently author their own tests. The effectiveness of tests depends upon many factors, however, it is clear that the quality of each individual item is of great importance. This study sought to determine the quality of teacher-authored test items in terms of nine rating factors.

Background

Most testing in schools employs teacher-made tests (Haynie, 1983, 1990, 1991; Herman & Dorr-Bremme, 1982; Mehrens & Lehmann, 1987; Newman & Stallings, 1982). Despite this dependance upon teacher-made tests, Stiggins, Conklin, and Bridgeford (1986) point out that "nearly all major studies of testing in the schools have focused on the role of standardized tests" (p. 5).

Research concerning teacher-constructed tests has found that teachers lack understanding of measurement (Fleming & Chambers, 1983; Gullickson & Ellwein, 1985; Mehrens & Lehmann, 1987; Stiggins & Bridgeford, 1985). Research has shown that teachers lack sufficient training in test development, fail to analyze tests, do not establish reliability or validity, do not use a test blueprint, weight all content equally, rarely test above the basic knowledge level, and use tests with grammatical and spelling errors (Burdin, 1982; Carter, 1984; Gullickson, 1982; Gullickson & Ellwein, 1985; Hills, 1991). Technically their tests are simplistic and depend upon short answer, true-false, and other easily prepared items. Their multiple-choice items often have serious flaws--especially in distractors (Haynie, 1990; Mehrens & Lehmann, 1984, 1987; Newman & Stallings, 1982).

A few investigations have studied the value of tests as aids to learning subject content (Haynie, 1987, 1990, 1991; Nungester & Duchastel, 1982). Time on-task has been shown to be very important in many studies (Jackson, 1987; Salmon, 1982; Seifert & Beck, 1984). Taking a test is a time on-task learning activity. Works which studied testing versus similar on-task time spent in structured review of the material covered in class have had mixed results, but testing appears to be at least as effective as reviews in promotion of learning

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(Haynie, 1990; Nungester & Duchastel, 1982). Research is lacking on the quality of tests and test items written by technology education teachers.

Purpose

The purpose of this investigation was to study the quality of technology education test items written by teachers. Face validity, clarity, accuracy in identifying taxonometric level, and rates of spelling and punctuation errors were some of the determinants of quality assessed. Additionally, data were collected concerning teachers' experience levels, highest degree held, and sources of training in test construction. The following research questions were addressed in this study:

1. What types of errors are common in test items?
2. Do the error rate or types of errors in teacher constructed test items vary with demographic factors?
3. Do teachers understand how to match test items to curriculum content and taxonometric level?

Methodology

Source of Data

Between April 23, 1988 and January 8, 1990, a team of 15 technology education teachers worked to develop test items for a computerized test item bank for the North Carolina State Department of Public Instruction (SDPI). The work was completed under two projects funded by SDPI and directed by DeLuca and Haynie (1989, 1990) at North Carolina State University. The data for this study came from the items developed in those projects.

Test Item Authors

The teachers were selected on recommendation of supervisors, SDPI consultants, or teacher educators. All were recognized as leaders among their peers and most had been nominated for teacher of the year or program of the year commendation. They were all active in the North Carolina Technology Education Association and supported the transition to the new curriculum. Table 1 displays demographic data concerning the test item authors.

Table 1
Profile of Authors' Demographic Factors

Author	Years of Teaching Experience	Highest Degree	Undergraduate Test & Measure Courses	Graduate Test & Measure Courses
1	9	B.S.	0	0
2	5	B.S.	1	0
3	23	B.S.	0	0
4	4	B.S.	0	1
5	5	B.S.	0	1
6	23	M.Ed.	0	1
7	19	M.Ed.	0	1
8	17	M.Ed. + 2 yrs.	0	2
9	25	M.Ed.	0	0
10	5	M.Ed.	0	0
11	7	M.Ed.	0	0
12	7	B.S.	0	0
13	7	M.Ed.	0	0
14	15	B.S.	1	0
15	5	B.S.	1	1

Training of Authors

Teachers came to the university campus for a workshop on April 23, 1988. Project directors oriented teachers to the computerized test bank, reviewed the revised technology education curriculum, and explained how to develop good test items. A 13 page instructional packet was also given to each author. It should be noted that the training session and instructional packet may confound attempts to generalize these findings.

The authors were required to develop and properly code six items which were submitted for approval and corrective feedback before they were allowed to proceed. The teachers who authored the items were paid an honorarium for their services.

Editing and Coding of Items

Each item was prepared on a separate sheet of paper with a coding sheet attached and completed by the teacher. The coding sheet identified the author, the specific objective tested, the taxonometric level, and information for the computerized system. The project directors edited the items with contrasting colored felt tip pens on the teachers' original forms.

Design of this Study

The data for this investigation were the editing markings on the original test items submitted by the teachers. Scores for 9 scales of information were recorded for analysis. Each of the scales was established so that a low score would be optimal. The scales were Spelling Errors (SE), Punctuation Errors (PE), Distractors (D), Key (K), Usability (U), Validity (V), Stem Clarity (SC), Taxonomy (TX), and an overall Quality (Q) rating. After all of the ratings were completed, the General Linear Models (GLM) procedure was used for F testing and the LSD procedure was used when t-tests were appropriate.

Findings

Spelling Errors (SE)

The frequency and percentage of scores for the 993 items on the nine ratings, and mean scores of each factor, are shown in Table 2. An item's SE rating indicates how many words were misspelled in the item. There were 98 items (10%) which had one or more spelling errors. Spelling errors are detrimental to good teaching and testing. However the literature shows that this problem is common to other disciplines.

Table 2
Ratings of Test Item Quality

Rating Category	Score	Frequency of Items With Each Score	% of Items/ Score	Mean Item Score	SD
Spelling Errors (SE)	0	895	90.1		
	1	76	7.7		
	2	11	1.1		
	3	6	0.6		
	4	3	0.3		
	5	1	0.1		
	6	1	0.1		
SE Totals	---	993	100%	0.14	0.52
Punctuation Errors (PE)	0	735	74.0		
	1	220	22.2		
	2	25	2.5		
	3	4	0.4		
	4	1	0.1		
	5	8	0.8		
PE Totals	---	993	100%	0.33	0.68

Table 2 (cont.)

Distractors (D)		0	447	45.0		
		1	398	40.1		
		2	95	9.6		
		3	30	3.0		
		4	9	0.9		
		5	14	1.4		
	D Totals	---	993	100%	0.79	0.96
Key (K)		0	889	89.5		
		2	104	10.5		
	K Totals	---	993	100%	0.21	0.61
Usability (U)		0	249	25.1		
		1	265	26.7		
		2	159	16.0		
		3	131	13.2		
		4	74	7.5		
		5	50	5.0		
		6	21	2.1		
		7	11	1.1		
		8	16	1.6		
		9	17	1.7		
	U Totals	---	993	100%	2.02	2.04
Stem Clarity (SC)		0	602	60.6		
		1	352	35.4		
		2	39	3.9		
	SC Totals	---	993	100%	0.43	0.57
Taxonomy (TX)		0	835	84.1		
		1	124	12.5		
		2	34	3.4		
	TX Totals	---	993	100%	0.19	0.47
Quality (Q)		0	208	20.9		
		1	235	23.7		
		2	200	20.1		
		3	129	13.0		
		4	74	7.5		
		5	58	5.8		
		6	42	4.2		
		7	17	1.7		
		8	10	1.0		
		9	12	1.2		
		10	2	0.2		
		11	3	0.3		
		12	1	0.1		
		13	1	0.1		
		14	1	0.1		
		15	0	---		
		16	0	---		
		17	1	0.1		
	Q Totals	----	993	100%	2.28	2.20

Note. There were 993 items.

The authors were compared on each of the scales to determine whether they differed significantly and to see if similar or dissimilar errors were made by different authors. On the spelling errors factor authors were found to differ significantly: $F(14, 978) = 11.99$, $p<.0001$. Follow-up analysis with the LSD procedure showed that 5 authors had significantly fewer spelling errors and 3 authors had more than the average number of errors in spelling (Table 3). Two of the authors with numerous spelling errors also had other defects and were rated significantly worse in the overall Quality (Q) rating (authors 1 and 9). However, only 1 of the authors with a significantly low rate of spelling errors was rated favorably in the Quality rating, so spelling accuracy alone is insufficient to identify good test item writing ability.

Table 3
Means of each Author on the 9 Rating Categories

	N	Per Item Means								
Author	Items	SE	PE	D	K	U	V	SC	TX	Q
1	92	0.29 **	0.37	1.29 **	0.68 **	2.95 **	0.09 *	0.53	0.24	3.51 **
2	102	0.01 *	0.17 *	0.59	0.12	1.34	0.16	0.38	0.11	1.54
3	32	0.21	0.41	1.16 **	0.44	2.88 **	0.28 **	0.47	0.59 **	3.56 **
4	103	0.17	0.39	1.28 **	0.33	2.76 **	0.16	0.49	0.17	2.98
5	100	0.17	0.39	0.94	0.24	3.01 **	0.22	0.67 **	0.29 **	0.92
6	56	0.11	0.38	1.14 **	0.32	2.25	0.32 **	0.43	0.34 **	3.04
7	62	0.26 **	0.24	0.55	0.26	1.77	0.13	0.39	0.35 **	2.18
8	104	0.07 *	0.22	0.71	0.17	1.70	0.38 **	0.38	0.19	2.13
9	42	0.43 **	0.83 **	1.21 **	0.09	3.21 **	0.26 **	0.79 **	0.29 **	3.90 **
10	50	0.04 *	0.98 **	0.16 *	0.00 *	1.46	0.00 *	0.28 *	0.04 *	1.50
11	46	0.00 *	0.28	0.74	0.00 *	1.85	0.13	0.35	0.09 *	1.59
12	28	0.21	0.07 *	0.39	0.00 *	1.04 *	0.11	0.29	0.18	1.25 *

Table 3 (cont.)

13	82	0.06 *	0.01 *	0.14 *	0.02 *	0.71 *	0.30 **	0.23 *	0.07 *	0.85 *
14	48	0.13	0.31	0.29 *	0.00 *	1.19 *	0.04 *	0.42	0.08 *	1.27 *
15	46	0.09	0.17 *	0.87	0.04 *	1.54	0.00 *	0.26 *	0.00 *	1.43
Grand Means	---	0.14	0.33	0.79	0.21	2.02	0.19	0.43	0.19	2.28

Note. There were 993 items.
* Significantly low (better), p<.05.
** Significantly high (worse), p<.05.

Years of teaching experience and other demographic data were presented in Table 1. Teachers were divided into two groups of experience level: fewer than 8 years experience (8 teachers who authored 557 items), and more than 8 years experience (7 authors, 436 items). On the Spelling Errors factor these groups were compared and there was a significant finding of $F(1, 991) = 10.48$, $p<.0012$. Follow-up analysis by the LSD procedure showed that the less experienced teachers had significantly fewer spelling errors. None of the other demographic variables were found to differ significantly on the rate of spelling errors.

Punctuation Errors (PE)

The PE rating (Table 2) was the total number of punctuation errors. The most frequent errors were omission of punctuation at the end of the stem or use of the wrong punctuation there. Frequently statements were ended with question marks or stems which should have ended with a colon were left with no punctuation. This score may be inflated spuriously by those unique errors which may not have been made in normal prose writing by the same teachers. Among the 15 authors, a significant difference was found in the PE category: $F(14, 978) = 8.12$, $p<.0001$ (Table 3). No significant differences were found among any demographic variables on the rate of punctuation errors.

Distractors (D)

Errors in distractors other than spelling or punctuation were summed in the Distractors (D) category (Table 2). Frequently these errors either eliminated distractors or targeted the correct answer due to incompatibility between the stem and the alternatives because of lack of agreement in: singular-plural, introductory article, tense, or in one case even gender.

A significant finding of $F(14, 978) = 13.37$, $p<.0001$ was attained and follow-up by LSD showed that 3 authors (10, 13, and 14) had significantly lower error rates. Two of those 3 authors who had superior distractors were also among the best in the overall Quality rating. All three of the authors who rated poorest in the overall Quality rating, also rated significantly worse in this Distractors category. Apparently this is one aspect of test writing which needs to be stressed to teachers.

All 4 of the demographic variables studied were found to be significantly related to errors in distractors: Years of experience, $F(1, 991) = 10.55$, $p<.0012$, the less experienced teachers authored superior distractors; Highest degree held, $F(1, 991) = 23.21$, $p<.0001$, those with graduate degrees wrote better distractors; Undergraduate courses, $F(1, 991) = 11.46$, $p<.0007$, those who had taken an undergraduate testing and measurement course prepared better distractors; and Graduate courses, $F(1, 991) = 13.23$, $p<.0003$, graduate courses also appeared beneficial.

Key (K)

The Key (K) rating simply indicates whether the answer marked in the teacher's original version of the item was indeed correct. Since incorrect keying was considered a more damaging error than a misspelled word or other common error, a rating of 2 was given for incorrectly keyed items. This resulted in greater increase of the summation categories (Usability and Quality) due to incorrect keying than for other types of errors. Regrettably, 10.5% of the items were keyed incorrectly (Table 2).

The authors differed significantly in the Key rating: $F(14, 978) = 8.01$, $p<.0001$. Table 3 shows the teachers' means and the results of LSD comparisons. Six authors keyed their items more accurately than others and one teacher was very inaccurate in keying. Teachers with less than eight years of experience keyed more accurately than more experienced teachers, $F(1, 991) = 19.82$, $p<.0001$; and teachers with graduate degrees also more accurately keyed their items, $F(1, 991) = 12.90$, $p<.0003$.

Usability (U)

The Usability (U) rating was found by counting all proofreading and editing marks of all types on the teachers' original forms--thus it included the sum of all the above categories plus other errors and defects not included in them. An example of an error which would not be counted in the first four ratings but would be included here is an item which begins with a blank. Such an item would have a U rating which equalled the sum of all SE, PE, D, and K ratings plus 1.

The teachers did differ significantly when compared on the Usability of their items: $F(14, 978) = 11.99$, $p<.0001$. Comparisons via LSD found that three teachers developed items with superior usability and five teachers authored significantly less usable items (Table 3). The teachers with fewer than eight years of experience developed more usable test items according to this rating: $F(1, 991) = 7.47$, $p<.0064$. Teachers with graduate degrees wrote more useful items, $F(1, 991) = 16.42$, $p<.0001$, and both undergraduate and graduate testing and measurement courses appeared to be effective in helping teachers develop usable items: Undergraduate courses, F(1, 991) = 26.68, p<.0001; and Graduate courses, F(1, 991) = 12.05, p<.0005.

Validity (V)

Items were carefully read and compared to the objectives they were intended to test. A Validity (V) rating of 0 indicated the item clearly possessed face validity. An item which was obviously off the subject was rated 2 and items which tested information immediately adjacent to the intended information were rated 1 to indicate that validity was questionable.

The authors differed significantly in how valid their items appeared to be: F(14, 978) = 3.99, p<.0001. It is noteworthy that the Validity rating did not necessarily correspond to others in the study. One of the authors (number 1) who rated significantly better in terms of validity was one of the worst rated authors in five other categories. Likewise, one other author (number 13) who rated superior in eight other categories (including Q) was significantly worse in the Validity category.

The findings related to the demographic variables were: Less experienced teachers wrote more valid items, F(1, 991) = 4.32, p<.038; teachers with only Bachelor's degrees wrote more valid items than those with graduate degrees, F(1, 991) = 11.47, p<0007; teachers who had experienced undergraduate test and measurement courses submitted more valid items, F(1, 991) = 9.29, p<.0024; and graduate courses also helped teachers write more valid items, F(1, 991) = 10.01. p<.0018.

Stem Clarity (SC)

Stem Clarity (SC) was a subjective rating indicating how clearly understandable the stem appeared. If the item's stem seemed clear enough to lead knowledgeable students to the correct response, regardless of other types of errors (SE, PE, D, K, U, or V ratings), then that item was rated 0 in the SC category. Items which were confusing to read with no clear purpose set forth in the stem were rated 2. Items which would likely work but had some element of confusion were rated 1. Table 2 shows that most items were judged to be reasonably clear in intention.

The finding of F(14, 978) = 4.57, p<.0001 documents that teachers did vary in their ability to write clear item stems. It would seem reasonable to assume that authors who made many spelling and punctuation errors would also have difficulty wording their stems clearly. This, however, was not true in these findings. Of the demographic factors investigated, only highest degree held was related to the ability to prepare clearly worded stems: F(1, 991) = 6.34, p<.0120, teachers with graduate degrees developed superior items in terms of stem clarity.

Taxonomy (TX)

The Taxonomy (TX) rating indicates the extent to which teachers accurately identified the taxonometric level of the cognitive domain for each item. Teachers prepared items to match specific objectives and then coded them. The codes used were derived from the first three levels of Bloom's Taxonomy: 1 indicated simple knowledge, 2 indicated comprehension, and 3 indicated application or higher levels of learning.

Of the 993 items prepared for the test item bank, the authors indicated that they felt 559 (56%) operated at level 1 (knowledge), 379 (38%) operated at level 2 (comprehension), and only 55 (5.5%) operated at level 3 (application or above). The rating in the TX category assigned for this study indicates how well, in the researcher's judgement, the item authors had accurately identified the proper taxonometric level. This was done after reading the objective to be tested by each item and then carefully reading the item to see if it operated at the level indicated by the teacher. A rating of 0 in the TX category indicates that the item appeared to be accurately coded by the teacher. A rating of 2 indicated that there was a clear mismatch between the level at which the teacher desired the item to function and the level at which the researcher judged the item would actually operate. Ratings of 1 in the TX category indicate that the researcher felt the author's coding was questionable.

Table 2 shows that 84% (835) of the items had been correctly coded for taxonometric level. Teachers did vary significantly in their ability to code items according to taxonomy: $F(14, 978) = 5.20$, $p<.0001$. All teachers who rated poor in this rating also had poor ratings in at least one other category, most rated poor in at least two others. Teachers who rated superior in the TX rating also rated superior in at least two other ratings. Teachers with less than 8 years of experience were significantly more accurate in coding by taxonomy than the more experienced teachers, $F(1, 991) = 21.08$, $p<.0001$. Undergraduate test and measurement courses, $F(1, 991) = 9.29$, $p<.0024$, appeared to be helpful in enabling teachers to identify the correct taxonometric level of test items, however, graduate courses were not found to be a significant factor here, $F(1, 991) = 2.65$, $p<.0711$.

Quality (Q)

The overall Quality of the test items was summarized in the Q rating. The Q rating was found by summing all of the other ratings except Usability (U), which was already a partial summation. The Q ratings (Table 2) range from 0 (an item judged to need no editing of any sort and believed to operate exactly as the submitting author had intended) to a high value of 17.

A finding of $F(14, 978) = 14.79$, $p<.0001$, shows that teachers differed in Q ratings (see Table 3). All of the teachers who differed significantly in the Q rating had also differed in several other categories. Experienced teachers prepared items with poorer overall quality than inexperienced teachers: $F(1. 991) = 20.67$, $p<.0001$. Teachers with graduate degrees produced items identified to have better quality: $F(1, 991) = 13.44$, $p<.0003$. Undergraduate test and measurement courses helped teachers develop higher quality items, $F(1, 991) = 35.45$, $p<.0001$, and so did graduate courses, $F(1, 991) = 11.14$, $p<.0009$.

Discussion

Though the sample included only 15 teachers, the findings presented in this study suggest that technology education teachers have some of the same difficulties in developing useful test items that teachers in other disciplines face. Despite the fact that these carefully selected teachers were given special training to improve their items, less than 21% of the items they prepared were flawless. Earlier works identified spelling, punctuation, grammar, clarity, validity, reliability, taxonometric level, problems in distractors, and other mechanical factors to be problem areas in teacher-made tests. Six of these problems were investigated in this study. Additionally, errors in keying items, a general overall quality assessment, and preparation of technology education teachers to write test items were factors considered by this study.

It was demonstrated that teachers differed significantly in their ability to prepare good test items, and that undergraduate and graduate courses in testing and measurement, though they appear to be helpful in many ways, are not taken by all teachers. These courses improved teachers' ability in developing distractors, and preparing valid and useful items. Undergraduate courses were also shown to help teachers identify the proper taxonometric level of their items.

Teachers with graduate degrees developed items which were superior in 5 of the ratings in this study: distractors, keying of items, usability, stem clarity, and overall quality. However, teachers who had only Bachelor's degrees were significantly better in developing items judged to have good face validity.

Teachers with fewer than 8 years of experience developed items with better overall quality (Q rating) than those who had more experience. The less experienced teachers significantly outperformed their more experienced peers on 7 of the quality factors studied: spelling, distractors, key accuracy, usability, validity, taxonomy, and overall quality. These findings were unanticipated and could possibly be explained by any of several competing theories. Perhaps teachers who have been in the profession longer than 8 years have begun to burn out and have less time or patience to devote to extra assignments such as the test item development projects in which they participated. Alternatively, it could simply be true that teachers who earned their degrees in recent years had received better preparation to develop test items. Still another possibility is that this could be a spurious finding due to the small sample size (15 teachers) or some other unknown error in sampling.

This investigation did not examine the validity of teachers' total tests. It was limited to study of individual items. Often, when an item was judged to lack face validity, another item for an adjacent objective was better suited and the pair of items together was valid to test the two objectives. This informal finding would be difficult to quantify and demonstrate. However, since 85% of the items were judged to have good face validity and only 4% were judged to be invalid, if any sizeable portion of the remaining 10% (judged marginally valid) were in fact usefully valid or could become valid when switched with neighboring items on the same test, then it would be safe to conclude that these technology teachers can develop reasonably valid tests.

Previous research has shown tests to be time on-task activities which promote learning of the subject matter tested. One criticism of teacher-made tests has been that they waste time. If the tests are good ones then much of the time devoted to them may be well spent. However, poorly developed tests would still be a waste of time for learning and evaluation purposes. This study identified several weaknesses in test items developed by teachers. Other factors, such as selection of different types of items for differing objectives, total test validity, problems in scoring and grading, instructions to students about tests, and others could not be addressed in this particular study--but they remain as important research problems. These questions need to be answered before meaningful conclusions can be drawn about the learning value of time students spend taking teacher-made tests.

It is concluded that technology teachers could be better prepared to develop tests if more of them were required to take a testing and measurements course. It is also concluded that the teachers in this sample are generally capable of developing valid test items, but that the items teachers prepare vary in the 9 aspects of overall quality as predicted by previous research.

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Minority Recruitment and Retention Problems and Initiatives in Higher Education: Implication for Technology Teacher Education

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Recruiting and retaining minority students are growing concerns for leaders of colleges and universities across the United States. For a brief period, universities experienced steady progress at opening doors of higher education to minority students. For example, from 1960 to 1975, the number of black students in higher education rose from 150,000 students to approximately 1 million (Green, 1989). Unfortunately, enrollments of black students have remained at a plateau. With the exception of Asian students, participation rates of other minority groups in higher education have also remained stagnant. Further, the retention rates are low for minority students who have chosen to attend college. A recent report by the National Association of Independent Colleges and Universities found that 54% of Hispanic students and 63% of black students who had enrolled in four-year colleges had dropped out for good within six years (cited in Wilson, 1990). Although university leaders have confronted the problems of recruitment and retention on a national level, the issues have not been resolved. A growing chasm is reflected in the rates of participation of white and minority students in higher education (Carter & Wilson, 1989).

Technology teacher educators are also concerned about the recruitment and retention of minority students. As a profession, technology education needs minority teachers who can serve as role models to the increasing numbers of minority students in American schools. Further, minority leaders are greatly needed to strengthen the technology teaching field and its respective professional associations. Increasing the number of minority teachers in technology education should lead to positive results in recruiting minority students for technology education programs (Westbook, 1986). These are desirable goals, but what actions are needed by technology teacher educators to make sustained progress toward them? The purpose of this article is to review problems and

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initiatives associated with minority recruitment and retention in higher education and discuss implications for technology teacher education.

The Growing Importance of Minority Recruitment and Retention

Presidents of universities and deans of colleges of education have depicted minority recruitment and retention as vital issues for higher education. Demographic projections have indicated that an increasing percentage of students in elementary and secondary schools will be minority students. A recent report sponsored by the Western Interstate Commission for Higher Education and the College Board, *The Road to College: Educational Progress by Race and Ethnicity* (1991), stated that the proportion of graduates who are minority group members is expected to increase from 22% in 1986 to 28% in 1995 (cited in Evangelauf, 1991). The study showed that all of our southern perimeter states, from California to North Carolina, project proportions of graduates who are minority group members to be above 30%. Unfortunately, those minority groups are not currently well represented and are not expected to be comparably represented in the near future in the teaching ranks. For example, data presented by *Teacher Magazine* listed 93% of the beginning teachers of 1990 as white (cited in Work-America, 1990, May). This statistic is a marked contrast to the expectation that one third of the U.S. population will be people of color by the year 2000 (McCubbin, 1990).

Many technology teacher education departments desire to increase the number of minority students in their preservice programs--yet they are struggling for meaningful ways to accomplish this goal. The literature base on minority recruitment and retention lacks studies that might connect the topic directly to technology teacher education. However, technology teacher educators can begin to sense the magnitude of the issue by examining the expanding body of literature regarding minority participation in higher education.

A book published by the American Council on Education, *Minorities on Campus: A Handbook for Enhancing Diversity* (Green, 1989, p. 2-3), presented the following data related to minority participation on campuses.

> *Higher education's pool of students is increasingly made up of minority youth*. Of our 25 largest cities and metropolitan areas, half of the public school students come from minority groups. In 1985, 20 percent of the school-age population was minority; in 2020, that figure will rise to 39 percent.
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> *College attendance by black students has slowed; the gap in participation between whites and blacks is growing*. Between 1967 and 1975, the percentage of black high school graduates 24 years old or younger that were enrolled in or had completed one or more years of college rose from 35 percent to 48 percent; over the same period, the corresponding rate for whites grew much more slowly from 51 to 53 percent. However,

between 1975 and 1985, while the college participation rate for white youths continued to climb to 55 percent, the rate for blacks dropped to 44 percent. Recently released figures indicate that, in 1986, the rate for blacks rose to 47 percent.

The rate of college attendance for Hispanic youths has declined in the last decade. While the number of Hispanic students enrolled in college has increased significantly since 1975, the rate of attendance declined slightly between 1975 and 1985, from 51 percent to 47 percent.

College attendance by American Indian students lags far behind black and Hispanic attendance. A recent report by the Cherokee Nation found that only 55 percent of U.S. Indians graduate from high school, and of these, only 17 percent go on to college.

Minority students are concentrated in community colleges. In the fall of 1986, over 55 percent of the Hispanics and just over 43 percent of the blacks attending college were enrolled in two-year institutions. Few of these students ever go on to attend or graduate from four-year institutions.

Black and Hispanic students are far less likely than white students to complete a degree. Among 1980 high school seniors who enrolled in college, 21 percent of the white students, compared with 10 percent of the black students and 7 percent of the Hispanic students, earned a bachelor's degree to higher degree by spring 1986.

Blacks attending historically black colleges and universities (HBCUs) are more likely to complete a degree than those attending predominantly white institutions. In 1984-85, HBCUs awarded 34 percent of baccalaureate degrees earned by blacks while enrolling 18 percent of black students.

As one ponders the preceding information, questions surface in the search for remedies to these concerns: Why is the participation gap increasing between minority and white students on our campuses? Why are attrition rates higher for minority students? What efforts have achieved success at increasing minority recruitment and retention? Leaders of our universities are struggling to find solutions to these pressing questions.

A study conducted by the American Council on Education titled “Campus Trends 1989” found that a vast majority of colleges are attempting to increase minority recruitment and retention on their campuses. Despite the efforts of these institutions, nearly two-thirds of their leaders rated their abilities to recruit black and Hispanic students as only fair or poor. Senior administrators at approximately 370 institutions participated in this annual survey (cited in Magner, 1989, July 26). Some of the administrators who took part in the survey were not confident about whether their institutions provided supportive environments for black and Hispanic students. Forty percent responded that the environment for black and Hispanic students was fair or poor at their institutions.

Attendees at the 1989 annual meeting of the Education Commission of the States collectively agreed that a need exists to attract more minority students to universities. State policy makers were divided, nonetheless, over what approach should be used to attract those minority students. They disagreed over whether states should use “a carrot or a stick” approach to urge colleges and universities to increase the emphasis on minority recruitment and retention. In light of the need to improve minority students' academic achievement, considerable debate ensued over whether radical changes were needed in today's educational system (Cage, 1989, July 26).

If corrective actions are not taken, problems with minority recruitment and retention might get worse as opposed to better. According to Wayne E. Becraft, the interim Executive Director of the American Association of Collegiate Registrars and Admissions Officers, contradictory goals are in place that hinder minority recruitment and retention. Large public universities are tightening admission requirements and attempting to recruit minority students at the same time. Colleges are trying to recruit minority students without a clear cut plan for doing it. Without programs that offer support, such universities are building failure (cited in Evangelauf, 1989, February 8).

Minority Recruitment and Retention Programs in Action

Several colleges and universities have implemented minority recruitment and retention programs. The following examples depict an array of strategies that might help an institution initiate a minority recruitment and retention program.

William and Mary. Programs initiated at William and Mary focus on raising the academic skills of black high school juniors. A summer program consists of a five-week term and is an attempt to increase the pool of eligible high school seniors and attract them to William and Mary. If these students enroll at William and Mary, they are assigned academic advisors who help the students with the transition to college (Jaschik, 1989, June 28).

Rutgers University. Rutgers is another institution that has suffered a serious decline in the number of minority students. In an attempt to battle this problem, the institution has created special mailings for minority students, conducted telephone contacts, issued personal invitations to campus receptions, established a scholarship program for high ability Black and Puerto Rican students, and initiated a seminar for minority high school students and their counselors. Much of Rutgers' effort at retention has focused on tutorial assistance and additional counseling for minority students (Kanarek, 1987).

Purdue University The School of Engineering and Technology, Purdue University at Indianapolis has developed a curriculum that uses computers to develop pre-college skills of students in grades 6-11 who participate in its Minority Engineering Advancement Program (MEAP). The program began in 1974 as a result of low enrollment levels of minority students in the schools of engineering and technology. The program is funded through a combination of private and university funding. Since the program's inception, 84% of all the program's participants have attended college and 58% of these majored in engineering or technology ("Recruiting Minority Students," 1989, September).

Texas Tech University. Statistics from the Texas State Board of Education indicated that Hispanic students comprised 30.4% of Texas student population in 1984, yet the number of employed Hispanic teachers has remained constant at about 12% from 1982-86. Furthermore, of those students who choose teaching as a career, data indicated that 90% were Anglo, 4.6% black, 2.8% Hispanic, and 1.4% Asian or Pacific Islander (Zapata, 1988).

Texas Tech University formed a partnership with a public school district in an effort to recruit and retain minority students. This effort is intended to make Texas Tech faculty members available to individual teachers and classrooms of the Lubbock Independent School District (LISD). Each faculty member will be used as a general classroom resource, exchange teacher and role model. This partnership is expected to help high school students make the transition to college and to help recruit and retain minority students at Texas Tech University (Ishler & Leslie, 1987, February 12-15).

Virginia Polytechnic Institute and State University. The Virginia Polytechnic Institute and State University uses a five-week summer program to facilitate the enrollment and retention of black college students. The program focuses on increasing skills in academic subjects; developing skills in interpersonal interactions with peers, faculty and administrators; developing self-confidence and self-awareness; gaining knowledge of the complex university structure, its rules, regulations and policies; and learning successful study methods and time management (McLaughlin et al., 1984, October 24-26).

Northern Illinois University. Northern Illinois University is renovating a program that is giving special help to minority students. The CHANCE Program helps minority students who are academically deficient upon admission by offering counseling, tutoring and basic skills classes in English, reading, speech and mathematics. The university is doubling the number of counselors in its CHANCE program and extending services to cover students' entire stay on campus.

The preceding examples of recruitment and retention strategies represent a small sample of ideas that have been tried by a handful of colleges. Programs at other universities may be as good or perhaps better, but the preceding programs were cited by the authors to exemplify the breadth of activities occurring on college campuses. Additional recruitment and retention strategies and examples may be gleaned from the documents *Recruiting Minority Teachers*, by the American Association of Colleges for Teacher Education (1991), and separate articles by Dorman and Holmes in the *Policy Briefs* (1990, Number 8) publication of the North Central Regional Education Laboratory.

Articulation with Community Colleges to Enhance Minority Recruitment and Retention

Although numerous approaches to minority recruitment deserve recognition (e.g., intervention with public schools, summer campus internships for visitation programs, articulation with historically black colleges), the authors believe that articulation among universities and community colleges merits special attention. Community colleges are quite often the point of access to postsecondary education and professional career exploration for many ethnic minorities. Estimates are that 54% of all Hispanic and 45% of all black enrollments in the postsecondary sector are in two-year colleges (Woods & Williams, 1987). These students make up 30% of community college enrollment yet they are the least likely groups to continue their education at four-year institutions (Watkins, 1990).

Researchers are beginning to identify variables that enhance transfers for minority students from community colleges to universities. Well over $10 million dollars were awarded between 1979 and 1987 by Ford and other foundations for projects and activities related to minority student transfer. For students to make progress toward the Baccalaureate degree, these projects and activities indicated that three sets of activities should occur: 1) easing a transition from high school to community college, including testing and placing students in the proper courses; 2) supporting the students through a variety of special interventions while they are enrolled in a community college; and 3) enhancing transfer to senior institutions through such strategies as coordinated financial aid packages, curriculum articulation, and regularly scheduled staff interaction (Cohen, Lombardi, & Brawer, 1988).

The Ford Foundation funded 24 community colleges to conduct activities that might increase the number of minority students who receive Associate degrees and then transfer to universities. Five institutions received continued funding for a second year, and each institution took a different approach in increasing the student flow to universities. The Cuyahoga Community College established a center for articulation and transfer that focused on linkages with high schools and four-year institutions. Liguardia Community College stressed the improvement of the flow of information to students. Miami-Dade Community College worked on areas such as mandatory testing and placement, extensive remedial instruction and enforced standards of academic progress. The Community College of Philadelphia stressed curriculum reform through staff development, and South Mountain Community College created a variety of student recruitment and support services ("An assessment of urban community colleges," 1988).

Rivera (1986) found that the four most common program components for community colleges to increase minority recruitment to four-year institutions were curriculum development, articulation, student transfer information and student services. Recruitment of community college minority students is a complex issue and needs a variety of programs which are unique and fit within the framework of an institution. For additional reading on this topic, the reader is referred to a publication jointly produced by the Academy for Educational Development and the College Entrance Examination Board, *Bridges to oppor-*

tunity: Are community colleges meeting the transfer needs of minority students? (1989).

Some Common Ground for Minority Recruitment and Retention

No one set of recommendations will apply to all universities that wish to increase the recruitment and retention levels of minority students. Such factors as the size of programs, populations that they serve, the regional economy, institutional goals and administrative and faculty commitments can alter the degree of success that might be obtained in recruiting and retaining minority students. However, those institutions that seem to reach a level of success more often than not start at the local level and then reach outward. Further, institutions that have experienced success in improving minority recruitment and retention have one common element: they have developed a comprehensive approach for planning and coordination (Green, 1989).

Institutions cannot examine the problem of recruitment and retention of minority students from the perspective of what's wrong with the student. Instead, an approach should be taken that asks the question, “What's wrong with our institution?” Such questioning might lead to the systematic self-analysis needed to initiate an overall institutional game plan as opposed to a piece-meal, fragmented manner for dealing with minority recruitment and retention (Bender & Blanco, 1987).

University officials will be conducting a disservice if they merely gather up minority students from the inner city and drop them off as incoming freshmen at a far away, rural institution of higher education. Many minority students from urban areas have received inadequate educations from academically and fiscally bankrupt school systems. A university located in a rural community may be a vastly different social, economical, and educational experience for minority students. The total experience and value structure of the university and its community might significantly affect minority students' decision to stay or drop out.

Universities should not focus on the quantity of minority students that are recruited, but the quality of the transitional efforts that will permit minority students of vastly different backgrounds to achieve success socially, economically, and educationally. A beginning point is for university faculty and administrators to collectively review policies and common practices that might create barriers to success for minority students. Minority students have a minimal chance of graduating without the benefit of a substantial institutional commitment to retention (Mancuso-Edwards, 1983, November 29).

Organizational influences that can improve minority recruitment and retention include developing programs that help students with academic preparation problems, emphasizing precollege programs in relation to elementary and secondary schools, addressing multicultural environments, resolving organizational dilemmas of separatist versus support programs for minority students, creating proactive approaches to financial aid and examining opportunities for on-campus housing (Crosson, 1987).

Implications for Technology Teacher Education

As opposed to minority student programs that merely focus on high enrollments, perhaps the following suggestions might be more appropriate for technology teacher education departments:

1. Establish networks of information and referral with local schools and community colleges. Technology teacher education departments need a well planned approach for recruiting and retaining minority students. Within that plan, establishing a network will permit a timely flow of information among industrial and technology education students and faculty at secondary schools, community colleges and technology teacher educators at universities. A well orchestrated network will have much better results than the once a year contacts that are typically arranged by student recruiters. A network will permit students and faculty to become familiar with technology teacher education programs and to recognize their strengths and weaknesses.
2. Technology teacher education programs do not need to start from scratch when building recruitment and retention efforts. We must learn from the practices that have been tested by others. Moe (1989), for example, found in the literature consistent identification of the basic requirements needed to foster minority recruitment and retention. Such enhancements can occur through institutional improvements including: a) academic assessment programs, b) tutorial and mentorship services, c) visible minority leadership and participation on campus, d) curriculum development, e) increased financial assistance, and f) supporting an environment that will stimulate learning in a multicultural setting. Some recruitment and retention programs (as described in this manuscript) have been operating for many years. Such models may be adapted to coincide with local community and institutional needs. Those characteristics of the community and institution must be carefully delineated to depict what variables might be viewed as enhancements or hindrances for recruiting and retaining minority students.
3. Technology teacher education departments should work in tandem with other campus offices and departments to increase the pool of minority students as opposed to competing with one another for the existing supply of minority students. For example, departments can collaborate to serve adult minority students through community based organizations, military programs, community colleges, public and private trade schools, apprenticeships, and organized labor. Constituents of these groups need to be aware of employment opportunities in technology education teaching.
4. Technology teacher educators should work actively with community based organizations. By establishing relationships with community based organ-

izations, they can gain understanding of cultural characteristics of that particular population.

Can Technology Education Make a Contribution?

The central theme of this article pertains to technology teacher education and the recruitment and retention of minority students. But what about technology education as a secondary school discipline? Can its content be established as a connecting force for minority participation in higher education? Is there any aspect of its subject structure that sets it apart from other curriculum areas in articulation with higher education? The technology education knowledge base lacks research and experience based conclusions to adequately answer the preceding questions. However, we can gain insight into possible connections by examining the linkages that have been created among other disciplines and the recruitment and retention of minority students.

The College Board has sponsored a project, called Equity 2000, to improve the college participation rate of students in six predominantly minority school districts. The program will require students of those districts to take algebra and geometry. The project is based on research indicating that low-income and minority students who master algebra and geometry attend and graduate from college at approximately the same rate as higher income white students (Collison, 1991, June 12). These findings should be of considerable interest to technology educators. Perhaps technology educators should seek avenues for using their curricula and laboratories to augment the success rate of minority students in algebra and geometry. Contemporary secondary curricula such as principles of technology, automated manufacturing, and computer aided drafting can serve as news linkages among technology education and other academic teachers for the purposes of creating integrative curriculum projects. Action research projects are needed in the field to pursue such endeavors.

Medical education is another field of study worthy of examination by technology educators. A report titled *Recruitment and retention of minority medical students in S.R.E.B. states*, by the Southern Regional Educational Board, was based on a survey of 45 medical schools. The two institutions that had the highest proportion of black students (East Carolina and East Tennessee) both had summer programs designed to help disadvantaged students improve their skills. At East Carolina University, the eight week summer program was considered to be *the single best predictor* for the student's success in medical school (Cage, 1991). Perhaps similar skill building summer programs could be cooperatively structured across secondary technology education programs and technology teacher education programs.

We need to look across disciplines to find examples of successful minority recruitment and retention programs. The declining number of minority teachers is a serious threat to the social ideals of public schools in a racially and culturally diverse democracy. Technology teacher education programs should confront this problem with idealism, innovation, initiative, and (hope-fully) added resources ("Work in Progress," 1989). Minority teachers can play a critical role as empathetic mentors for minority students and as non-stereotypical examples for majority students (Gill, 1989).

A singular solitary approach for minority recruitment will not adequately serve the diverse needs of blacks, Hispanics and/or Asians. Recruitment and retention of students representing these groups will require technology teacher educators to become a good neighbor to these populations. As good neighbors, we must try to establish long lasting friendships through networks, community based organizations, local schools and community colleges. Such relationships are needed so that we can become more involved in grooming minority students for college at an earlier age (Magner, 1990, July 26). As those friendships mature, we will have benefited from an increased knowledge base for serving the needs of minority students and greater success at recruiting and retaining minority students in technology teacher education programs.

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Reaction

Questioning the Language that We Use: A Reaction to Pannabecker's Critique of the Technological Impact Metaphor

Stephen Petrina

In Volume 3, #1 of the *Journal of Technology Education*, Pannabecker (1991) identified shortcomings in the language that has shaped perspectives within technology education, and raised an issue for dialogue. This essay is intended to extend Pannabecker's critique to include the metaphors of autonomous and advancing technology, and their supporting ideology of technological progress. Reasons for extended critique and a summary of contemporary debates on these issues in the history of technology are provided.

According to Pannabecker, the metaphor of "technological impacts," often used by technology educators to describe the relationship between technology and society, has shaped a "simplistic and inflexible" view of that relationship (p. 43). This metaphor has reinforced a mechanistic and deterministic view of technology; indeed, a view suggesting that technology determines social and cultural direction. Society and individuals merely roll with, and adapt to technological change.

Whether those embracing the "impact" metaphor would logically follow it toward this conclusion is not the issue. However, it is important that we become conscious of the assumptions that may be hidden within our language, and of the constraints that they place on our imagination and discourse, questions we ask, or problems that command our efforts. Dr. Pannabecker should be commended for his critique of the language often used in technology education and his suggestion that the impact metaphor be abandoned for its lack of complexity.

I would add that this metaphor and others be abandoned for additional reasons. While self-criticism of the way we talk about technology is certainly within the range of our obligations as educators, might it also be a key ingredient for engaging in dialogue with others who have similar interests? All

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things considered, our perspectives on technology, framed by metaphors that we use, can appear anachronistic and ahistorical. Assumptions within our language may in fact be contradictory to messages we wish to convey to students and may limit possibilities for meaningful dialogue with historians, philosophers, and others who are involved in the study of technology.

Closely related to, but excluded in Pannabecker's critique, are the issues of autonomous and advancing technology, technological progress, and their sometimes uncritical acceptance and use in technology education. Autonomous technology suggests that technology is self-determining and has a life of its own. This notion was prevalent in Ellul's (1962) critique of Western cultural values. Ellul argued that technology has become autonomous in that it is governed by itself rather than by any definition of cultural values. Ellul proposed a philosophical theory to explain his notions of technological autonomy and determinism. In this theory, the relationship of technology to culture is, as Pannabecker explained, understood in terms of a one-way causal impact. Technology, self-governing, is advancing forward. If autonomous, then the question of shaping the form, substance, and direction of technology through democratic participation is irrelevant. If advancing, one can merely hope to get out of its way or catch up with it. These notions tend to augment political passivity, as there is no point in attempting to direct an entity with a forward autonomous momentum. Technology is therefore considered to be beyond human control. Certainly in technology education, the consequences of this logic are considerable when one accepts the development of a technologically astute citizenry with democratic initiative as fundamental to the cause and movement.

Notions that technology autonomously advances and, in effect, impacts either positively or negatively on society are reflections of an ideology in which new technology is assumed to be socially progressive. Within frames of reference constituted through the ideology of technological progress, technology is “modern, Western, and science-based, [and] related to culture as an independent driving force demanding adaptive change from all other cultural institutions” (Staudenmaier, 1985, p. 144). Science and technology autonomously progress in a forward motion and, given these forces, people and cultures are expected to conform. Those who choose to question this progress are questioned themselves and labelled modern Luddites. Endorsement of this ideology is an endorsement for social inaction toward technological issues, as expertise is viewed as a requisite for action. Norms that are technical, such as efficiency and speed, are generally the only measures of technological progress. Hence, cross-cultural comparisons are at-base, generalizations related to superiority or inferiority. From a cultural relativist perspective, one can see how this ideology inspires something less than an affirmation of unique cultural values (Adas, 1989; Lasch, 1989). Human dignity, integrity and the value of life are blurred by the imperatives of technological progress (Glendinning, 1990; Mumford, 1964; Winner, 1986). As positioned in this ideology, the appeal of the impact and autonomously, advancing technology metaphors is also apparent (Marx, 1987; Staudenmaier, 1985, 1989).

These metaphors and their supporting ideology are salient in literature and popular rationales supporting technology education (e.g., Waetjen, 1987; Wolf, 1990; authors in: Dyrenfurth & Kozak, 1991; Wright 1991). These notions are deep rooted and have been socially constructed; consequently, we all share in their origins and use. The history of industrial education is characterized by a continuum of arguments for the educational legitimacy of both the content and the process of technology. These arguments have been understandably emotional and often predicated on their sensational appeal to the public and body politic. Also, considering the remarkable persistence of technological progress, transcending this ideology has been, and remains a struggle. This helps to explain the irony in the fact that as a profession, we have historically succumbed to this persistence while proclaiming that critical insight into personal and social interaction with technology is imperative in a democratic society. Similarly, credulity must also be seen as part of the explanation for the metaphors that we've employed. As Frey (1990) wrote, few of us have neither been prepared nor prepared ourselves for sufficiently addressing the nature of technology, and as a result, we risk being advocates of a “superficial curriculum” (p. 69). Our cause has remained deserving and our arguments wanting.

It seems then, that our educational mission has historical consistency and a form of contemporary consensus. However, our rationales have been inconsistent with our mission and have often succumbed to the ideology of progress. The logic of a rationale that is driven by economic rhetoric (e.g., international competitiveness demands technology education) and academic rhetoric (e.g., technology is a discipline) is problematic. The competitiveness rationale clouds a unique identity for technology education as vocational educators expand their curricula to reflect workforce and workplace needs. The notion of international competitiveness can also be interpreted as a popular metaphor for technological progress embraced during the past decade (Hill, 1989). At the same time, the logic of drawing on the idiom of the academic disciplines is flawed. Characteristically, disciplines are bound to methods of inquiry through which knowledge is generated, tested, and ultimately organized (Luetkemeyer, 1968; Thompson, 1978). Historians of technology, in their interpretations of human interaction with technology, have yet to discern anything that is indicative of “the technological method”! Likewise, engineering is not dependent on a single intersubjective method, and employs methods ranging from rule-of-thumb to scientific. “The technological method” defined by educators (e.g., Barnes, 1989, 1990; Todd, 1990; Savage & Sterry, 1990) is bereft of any historical or even contemporary basis. If it is a new phenomenon, it has avoided empirical testing. Having benefited from rhetoric, “the technological method” has organizational momentum and now seems somehow fit for assimilation into the minds of unknowing students. “The technological method” may be related to the epistemological problem of “how we, as a community of educators come to understand technology" as much as any language problem. Nonetheless, the question of "what language shall we use to talk about technology?" is, as Pannabecker suggested, crucial. This question has been central to historians of technology who, like technology educators, have struggled with traditions and their role in the academic community.

To be sure, critical commentary directed toward technology was present in the first half of the century (e.g. Mumford, 1934), but only lately has a body of scholarship been developed with a critical stance on this issue. Within the Society for the History of Technology (SHOT), there has been a commitment to rescue the history of technology from its mythic "heroic inventor", "success story", and "boundless progress" tradition. Mostly through the influences of SHOT, historians have worked to critically interpret technology in its social and cultural context. This commitment has generated historiographic and philosophical debate along with consensus on some issues (Cutcliffe & Post, 1989).

The "technological impacts", and "advancing technology-lagging society" metaphors, ultimately questions of causation in history, reflect the historical explanations of Ogburn (1923) and Burlingame (1938). Most historians of technology would conclude that it's "futile to attempt to trace social changes to technological innovations" (Daniels, 1970, p. 8). Not surprisingly, these popular conceptions of an earlier era are still adopted by general American historians. Historians of technology would cite a lack of any historical evidence to support notions of either autonomous technology or the related theory of technological determinism. The historical record does *not* suggest that technology "feeds on itself", advances autonomously, or has a life of its own. As for determinism, these historians have argued that "technology, in a word, is used to help people do better what they were already doing for other reasons, and what they are doing for other reasons determines the nature of their future technology" (Daniels, 1970, p. 8). Kranzberg (1986) suggested that the case is not so closed, and the theory of technological determinism would challenge historians for some time. In general, most have no problem with the idea of "reciprocal causation. . . technology and society mutually influence each other" (Layton, 1970, p. 29). Technologies have historically been reflections and manifestations of cultural values. They have been, albeit often faulty and always through the involvement of enfranchised and disenfranchised groups, designed, engineered, and managed by people.

The ideology of technological progress has recently received considerable attention in both the history and philosophy of technology. Critiques have focused on material progress as well as those technologies that help us to achieve less tangibles such as security, freedom, control, longevity, and justice (Adas, 1989; Goldman, 1989; Glendinning, 1990; Hill, 1989; Mumford, 1964; Winner, 1986). Because of the various facets to technological progress, comments on any genuine concensus would be suspect. Nonetheless, Staudenmaier (1985, 1989, 1990) and Smith & Reber (1989) can be read as synoptic summarizations on contextual interpretations in the history of technology. Staudenmaier (1989) maintained that

> historians of technology labor to situate each artifact within the limited, historically specific, value domains from which they emerged and in which they operate. They speak of "technologies," and not "Technology," of cultural options rather than inevitable progress. This approach attempts what history traditionally holds dear, the liberation of human beings by demythologizing false absolutes and by paying attention to the human context of change. . . . Responsible technology talk fosters a language of engagement where "Technology" is understood to be a variety of particular technologies, each carrying its own embedded values, each related to its own unique cultural circumstance. It is a language that reweaves the human fabric, reintegrating method and context, and inviting us all, technical practitioners and ordinary citizens alike, to engage in the turbulent and marvelous human endeavor of our times (pp. 285, 287).

Language that reflects the ideology of technological progress, with its suggestion of inevitability, obscures underlying human motives and an assessment of who is served and who is left out. According to Staudenmaier, only by adopting a critical stance toward technology and its concomitant talk of progress can we begin to act responsibly and democratize the technological design and decision making process.

One can get a sense of the alternatives to the language of progress and determinism by attending to the history of technology (e.g., Smith & Reber, 1989; Staudenmaier, 1985, 1989, 1990). It's evident that we've a lot to learn from historians about the "what" and "why" of technology. So do historians have much to learn from technology educators about the troublesome, yet rewarding human experiences of teaching and learning how to use and create technology. The use of the history of technology in technology education, and specifically teacher education programs, should be reconsidered. This issue, raised periodically in the profession, remains unresolved (DeLuca, 1976; Frey, 1990; Miller, 1984). If the history of technology weren't so rich in scholarship and relevance, one might be inclined to agree with Bensen (1984) who exclaimed that "if we. . . teach only the historical aspects of our technology, we are doomed to oblivion" (p. 4). The reasons for our course to oblivion are complex and the road has been at least partially paved with good intentions. It's as much a factor of "how" as it is of "what we teach" that will conjure up similar specters. By locating ourselves within a larger community that includes historians, philosophers, and sociologists, we can stay attuned to contemporary discourse on technology. It might be wise to reflect on Pannabecker's critique of technological impacts and the validity of language or rationales that may contradict our mission or inhibit meaningful dialogue.

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Book Review

Westrum, Ron. (1991). *Technologies & society: The shaping of people and things.* Belmont, CA: Wadsworth Publishing Company, $24.50 (paperback), 394 pp. (ISBN 0-534-13644-3)

Reviewed by Alan C. Finlayson

Technology educators and university students will find no better general introduction to the broader social issues and contexts of technology than this new book. What seems to be an acceleration in the rate of catastrophic failures of technological systems (Chernobyl, Bhopal, Challenger, and Three Mile Island to name but a few) has made the need for such a text all the more urgent. Westrum's general thesis is that the pace of technological change is more rapid than is the transformation of covalent social structures and institutions: "We have third generation machines [but] first generation minds." [p.5]

This work gives us a superb "grand tour" of a crucially important field that is simply not available elsewhere. There are, to be sure, many excellent but more specialized articles and books in the emerging field of the sociology of science and technology and the interested reader is guided to them by Westrum's extensive annotations and references.

Westrum's work is a fine example of applied scholarship. The text is a generalized tool for teaching and learning about the complexities and subtleties of the interactive relationships between technology and society. Westrum's writing is open and inviting and the ideas accessible precisely because the author has rigorously purged his work of the "priestly language" which is, unfortunately, the taken-for-granted hallmark of "serious scholarship."

Not only is this an excellent text for academic application, it could also be very usefully read and effectively employed by practicing engineers and managers of technologically intensive businesses and organizations. People in roles as diverse as military command and hospital administration could use the insights and broadly-drawn data from this book to improve their understanding and use of technologies.

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The book opens with a review of the history of our understanding of the relationships between culture, social organization, and technology. This ranges from Marx's emphasis on the inherent political content of technologies to the autonomous and deterministic theory of technology propounded by William F. Ogburn in the early 1920's to the presently growing influence of the view that technologies are "socially constructed." Westrum's own treatment is an even-handed and sustained synthesis of all of these more radical and uncompromising perspectives.

> This book is about the mutual shaping of people and things. It explores the interaction of people and technology in a changing society.It examines the social relations between people and milk bottles, parking meters, nuclear power plants, and many other technologies. It explores how people and technologies shape each other... [p.5]

The work is so well organized and transparently written that it is easy to overlook the fact that Westrum has accomplished one of the most difficult tasks in analytical sociology. His exegesis of the social/technical nexus weaves seamlessly through all levels of social organization and does so from multiple perspectives. A historical review of the role of innovative individuals flows into a discussion of how varying social structures and cultural environments influence the rate and direction of technological development. One chapter opens with a micro-study of the small firm that developed liquid hand soap, segues into an expanding analysis of the triangular dynamics of technology, corporate organization, and markets, moves on to examine the causes and conditions of social resistance to technologies, and closes with a look at the evolution of technological niches. Similar deft and thoughtful treatment is given to the interactive relationships with technology of our political, regulatory, and educational institutions.

Applied in its intended context this text will be a extremely useful and effective piece of work. Westrum's target audience is undergraduate students majoring in technological fields such as engineering and students who plan to concentrate on social studies of science and technology. It should also be a required text in courses that prepare technology educators for the nation's K-12 schools. Ideally, the course should be taught by a person well-versed in the sociology of science and technology. Like the best of such books, Westrum's work is thought-provoking and will surely give rise to questions that are not directly answered in the text.

However, it would be a pity if the readership of this superb and thought-provoking work was bounded by the walls of the academy. We live in a thoroughly and relentlessly technological world of our own construction. Every aspect of our lives is in some way dependent upon and affected by technology. The clothes we wear, the housing that shelters us, the work we do, the food we eat, even the air we breathe reflect our socially mediated technological choices. Anyone who's life and work intersects with technology--inventors, developers, designers, entrepreneurs, stylists, marketers, regulators, sponsors, opponents, competitors, users, and consumers of technology--could profit from an open-minded reading of Westrum's work. °

Editorial

Technology: The End of the Honeymoon?

John Eggleston

One characteristic innovation of the 1990s is already clear - the modification, dilution or even abandonment of the curriculum innovations of the 1980s. In subject after subject the 'excesses' of the previous decade are giving way to 'tried and tested methods' - led by Government and its influential advisers.

But there has been one shining exception - Technology. The spectacular developments of recent years were codified and packaged in full by the Working Group led by Lady Parkes, turned almost unchanged into Statutory Orders and a virtually new subject was introduced in primary and secondary schools with the blessing of almost the whole Government team. Now, suddenly the honeymoon seems over; the fall out is spectacular and of royal proportions.

Events began to take a downward turn when HMI found that all was not well with National Curriculum Technology and that in many schools, particularly secondary, it was not as well taught as that which had preceded it. Not so surprising, perhaps, that in the first year of a largely new product is should not be being delivered quite as well as its long standing predecessor. But the pre-election delay in publication, the frequent revisions and the succession of leaks created a gathering cloud over the subject area.

All this established an opportunity for the Engineering Council to commission Smithers and Robinson to a no nonsense investigation on the state of technology. They duly obliged, and their report Technology in National Curriculum - Get it Right said it all with a list of bullet points of instant media readiness.

The message was simple - prune the 'cerebral' loading in Attainment Targets 1, 1, and 4 and concentrate on the practical designing and making in Attainment Target 3.

A few days later, by a remarkable coincidence, the HMI report was at last published and the evidence of low standards was there for all to see. The

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weekend journalists on 31 May had a ready made story. The Sunday Times under a headline 'Patten to Revise Technology Teaching as Standards Slide', wrote:

> The findings reinforce widespread criticism of the emphasis in school technology lessons on 'Blue-Peter' activities involving cardboard, paper and egg boxes. Academics warned this weekend that it was putting Britain's industrial future at risk.

The tabloids duly followed and by Tuesday 2 June the *Daily Mail* had an exclusive:

> Action to improve technology teaching in schools will be ordered today by Education Secretary John Patten.
> His intervention follows severe criticism by Government inspectors of standards in a subject regarded as vital to Britain's economic future.
> It is feared thousands of youngsters are leaving school ill-prepared to take on the Germans. French and Dutch in the highly-competitive European jobs market.
> Industrialists and engineers have warned that children are learning 'too much waffle'.
> Mr. Patten himself believes much of the current project work in classrooms is either too theoretical or irrelevant to the needs of modern manufacturing.
> Today he will demand an end to the 'Blue Peter technology' which sees pupils making cardboard cut-outs instead of real tools of modern manufacturing.
> Today he will demand an end to the 'Blue Paper technology' which sees pupils making cardboard cut-outs instead of real tools or equipment.
> The Minister will insist that, in future, lessons must get back to basics by being more practical and skill-based.

A series of libel articles from Blue Peter must be imminent but this did not inhibit the *Mail's* leader writer who wrote:

> Once again woolly teaching methods are cheating our children, substituting an emphasis on talk and theory rather than developing real skills of use in the world of work outside the classroom.
> There has always been a streak in the educational establishment which finds practical things distasteful; teaching children how to earn their living as somehow wrong.
> Fortunately Education Secretary John Patten has shown these sniffy ivory-towered experts that he is just as tough as his doughty predecessor.

Events then moved at great speed. SEAC produced an instant change of weighting, Attainment Target 3, the practical component was increased to 40% 5, the other Attainment Targets suitably reduced. The National Curriculum Council, with astonishing speed, produced a document *National Curriculum Technology: The Case for Revising the Order* - only weeks after strident officer denials that of any intention of revision. John Patten duly obliged, within hours of the *Daily Mail* call, and launched an urgent review of Technology in the National Curriculum.

The short sharp Patten review will be, on grounds of urgency of course, an in-house HMI job with only marginal NCC involvement with recommendations for new Orders to be ready for consultation by Autumn. The planning blight problems in the schools will be enormous, rewriting of teaching materials and timetables, GCSE pupils working to the old Orders even after the new Orders are in place to mention a few. But this has not diminished the heady delight of the advocates of change. The Engineering Council was quick off the mark, the triumphant press release reported:

> Mr. Denis Filer, Eng, Director General of the Engineering Council, said today that Mr. Patten has responded positively and speedily to the recommendations made by the Engineering Council in its report on the subject.
> ‘This should put an end to the Mickey Mouse technology that had manifested itself in schools’, said Mr. Filer.
> He added: ‘We must seize this opportunity to get the subject right and to define it more precisely. Teachers should not be left to struggle to interpret the subject; they should receive specific guidance.’

Of course there are problems in delivering National Curriculum Technology. There are still difficulties of resourcing in many schools. Many teachers are ill or even unenthusiastic about the subject. Some of the projects are, quite frankly, appalling. One gave its Key State 3 pupils a problem - design a car to appeal to young motorists. Research involved scanning old motoring magazines, realisation required the shaping of a block of softwood using saw and sureform tools and the evaluation was by their fellow pupils' votes. Some (not all) of the new books produced by educational publishers offer a series of short cuts and soft projects that seriously short change the subject and offer little challenge to children and teachers. But there are also outstanding examples of work in technology that demonstrates and entrance childrens' creativity and imagination - and practical competence. The writer's annual experience of judging the Young Electronic Designer Awards confirms this abundantly.

But the real issues go beyond the delivery problems and are political and ideological. If we unpick the logic of the Daily Mail leader we can begin to see then. Teachers, trendy or traditional, have never been opposed to practical technology activities. But they have been deterred from making them available to all children because of the relentless pressure to study academic subjects to win the qualifications that lead to high flying careers. Although there are repeated attempts to change matters - it still disadvantages able children to offer them a ‘practical curriculum.’ Their chances of getting into prestigious undergraduate courses with ‘A’ levels in Art, Computer Studies and traditional Technology are remote. In the technological degree programmes, particularly Mathematics and Pure Science rule.

The pattern of qualification is exactly matched by the technological professions. The top people - architects, designers and professional engineered do not make things - they work with paper and make models - even using egg boxes. If they want to have something made they call in one of the lower status workers.

The 'crime' of National Curriculum Technology is that it is trying to make these 'intellectual' and expressive aspects of technology available to all children. Its an ambitious, brave and difficulty endeavor. It may not be universally successful - but should not all children have the opportunity? But there is a fundamental problem. If the endeavor succeeds it may confuse the social order by producing too many chiefs and not enough Indians. And even worse - because the emphasis on practical ability is relatively less - the Indians may be less skilled and even less willing to be skilled than before.

We are in great danger of diluting or abandoning one of the Century's most ambitious and well thought out innovations. It is an innovation that could transform our labour force and rekindle the huge creative power that characterised the first British industrial revolution.

Let us hope that the HMI review will respond to the Engineering Council's desire to get it right and steer a path through the delivery problems. But let us also hope that, in the process, it will not abandon the spectacular achievements in Technology education which have been achieved by cooperation between education and industry in the past twenty years. °

Technology Education: Prospectus for Curriculum Change

Michael R. Kozak

Starr (1988) documents the United States as being in an ever weakening global position. For example, he reports on the demand for an increasingly educated and technical work force and contrasts this with the supply of high school graduates ill equipped for either college or the work force. Many Americans find today's rapidly changing world a bewildering and alien place to live and to work as they intentionally, or unintentionally, recoil from the technical means upon which they must rely and try to cope and adapt (Bensen, 1991).

This editorial examines how the United States is failing in its attempt to educate and professionally prepare our youth. The critique is followed with a proposed technology education teacher preparation curriculum that attempts to reflect today's global, technological society.

United States Society Based on Globalization

A recurring theme in contemporary society is globalization. The expanding growth of world output crossing national boundaries, because of dramatic advances in transportation and information services, has advanced the concept of a one-world economy. Somewhere in the world, markets are open. Products are commonly produced in one country utilizing materials from a second country and exported for sale to still others.

No American firm can afford to assume that it is impervious to foreign competition. In addition, an increasingly larger number of United States firms are looking overseas for opportunities. A technology education teacher preparation curriculum should include the concept of globalization.

United States Society Based on Technology

Technology may be defined as the systems and objects or artifacts that are created using knowledge from the physical and social worlds (Friedman, 1980). Key descriptors of a definition for technology, according to Barnes' (1990) study include: a) innovation; b) invention; c) creativity; d) extension of human capabilities; e) system of tools, knowledge, and behaviors associated

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with the exploitation of the environment; and f) social, economic, political, and environmental impacts. A technology education teacher preparation curriculum should include the latest advances in technology.

United States Education: A Failing Grade

While globalization and technological changes are taken for granted in today's business and industrial arena, education seems to be much more inwardly-focused. The United States public educational system is not only supplying unprepared entrants for college and for the technical work place, but even worse, it is misleading them into believing they are qualified to compete successfully in a modern and demanding technologically global society (Meriam, 1991).

Most of the United States population is not being properly educated to function in the everyday world of the next century--a time in which technologically literate citizens must make critical decisions affecting the global community. For example, when asked in a Gallup poll what kind of work engineers perform, 35 percent of “average Americans” surveyed stated they run trains, manage boiler rooms, or simply do not know (Lohman, 1991). Over 3,000 students drop out of high school each day in the United States and 75 percent of American high school youth never graduate from college (Thomas, 1987).

Professional Preparation and Education

Japan's manufacturing is, for the most part, highly robotized, yet the educated human element is still a high priority. The Japan Productivity Center, established in 1950, contends that the basic view of productivity is a respect for people in order to promote human welfare (Orr, 1990).

Professional preparation programs in the United States tend to place less emphasis on general education (liberal arts) courses and a much greater emphasis on subject specialty courses. However, the Stanford Institute for Research on Educational Significance on High Technology has stated: “Everyone should have strong analytic, expressive, communicative, and computational skills as well as extensive knowledge of political, economic, social and cultural institutions” (National Advisory Council on Continuing Education, 1984, p. 8). A technology education teacher preparation program should include professional preparation and a liberal arts education.

Technology Education Program Development

Any technology education program development effort should take place within the concept of a defined totality. The human adaptive systems (ideological, sociological, technological), are a totality as identified by White (1959). Human adaptive systems are open systems which are dynamic, tend towards growth and differentiation, and stress a continued renewal process. Ideological systems are those that comprise basic belief systems such as values and social norms. Sociological systems refer to structured relationships among people. Technological systems pertain to the manipulation of the physical world to meet basic needs of survival and to extend human potential (Lauda & McCrory, 1986).

Major Concerns

Determining the appropriate distribution of professional preparation and liberal arts courses should be a major concern in a technology education teacher preparation curriculum. Zuga (1989) stresses that program development should be based on intellectual processes that also make critical thinking, problem solving, creativity, and self-confidence major concerns.

Public school instructors, by virtue of the fact that they are in daily contact with today's youth and tomorrow's possible leaders, must themselves be educated in the liberal arts, appreciate the globalization of society, and be professionally prepared to understand the concept of constant technological change.

Recent writers seem to stress this general approach to the study of technology. Kozak and Robb (1988) wrote that technology education emphasizes technology as a part of the humanities, the arts and the sciences, and can acquaint all persons with their technological environment so they can make rational decisions about their own lives and control their own destiny. Zuga (1989) stated: “The evolution of technology education goals has reflected a drift towards more liberal education ideals” (p. 34). According to Wright (1988), the technology educator should adopt the social/cultural approach for improving the awareness of how humankind interacts with technology. Perhaps at no other time in history is there a greater need for university technology education teacher preparation programs to be pro-active rather than reactive.

Suggested Program in Technology Teacher Education

The technology education teacher preparation curriculum should include, in addition to the latest technological advances, the following: a) state and university mandated requirements (these cannot be ignored), b) core curriculum courses, c) globalization concepts, and d) professional preparation courses. (see Table 1)

Table 1
Proposed Technology Education Teacher Preparation Program

State/University Mandated Courses			
History	6 s.h.	Political Science	6 s.h.

English	12 s.h.	Physical Education	4 s.h.
	Core Curriculum		
Art	3 s.h.	Music	3 s.h.
Chemistry	4 s.h.	Philosophy	3 s.h.
Computer Science	3 s.h.	Physics	4 s.h.
Dance/Drama	3 s.h.	Psychology	3 s.h.
Economics	3 s.h.	Sociology	3 s.h.
Mathematics	6 s.h.		
	Globalization Concept		
Foreign Language	12 s.h.	Cultural Diversity	6 s.h.
International Internship	6 s.h.		
	Professional Preparation		
Technology: Materials	9 s.h.	Technology: Energy	9 s.h.
Technology: Information	9 s.h.	Technology: Control	9 s.h.
Education Methods (Including Student Teaching)			18 s.h.
		Total	144 s.h.

If a liberal arts education is to be a major concern, then a core curriculum should be considered with courses, if possible, in every department in every college and/or school in a university.

To address “globalization”: a) communication skills in a second language such as Spanish, German, Japanese, or Russian; b) cultural diversity; plus c) an international internship would be possibilities.

Today's typical technology education program includes approximately 130 semester hours. However, a full-time student at a university could take 18 semester hours per semester for four years, a total of 144 semester hours. Therefore, Table 1 is an example of a proposed 144 semester hour technology education teacher preparation program that includes: a) state/ university mandated courses, b) a core curriculum, c) globalization concepts, d) professional preparation in technology and e) professional preparation for teaching.

Conclusion

An old story concerns giving a starving person a fish so that the individual will live for another day, or teaching the person to fish so as not to starve ever again. In today's world, with constantly changing technology, teaching a person to fish is no longer sufficient; the individual must be educated so that as fishing methods change, the individual will know how to learn to stay competitive and survive in the technological fishing industry of the future. In addition, with the technological advances in the fishing industry, the individual will have more free time and should also be educated to appreciate what the world has to offer.

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Miscellany

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