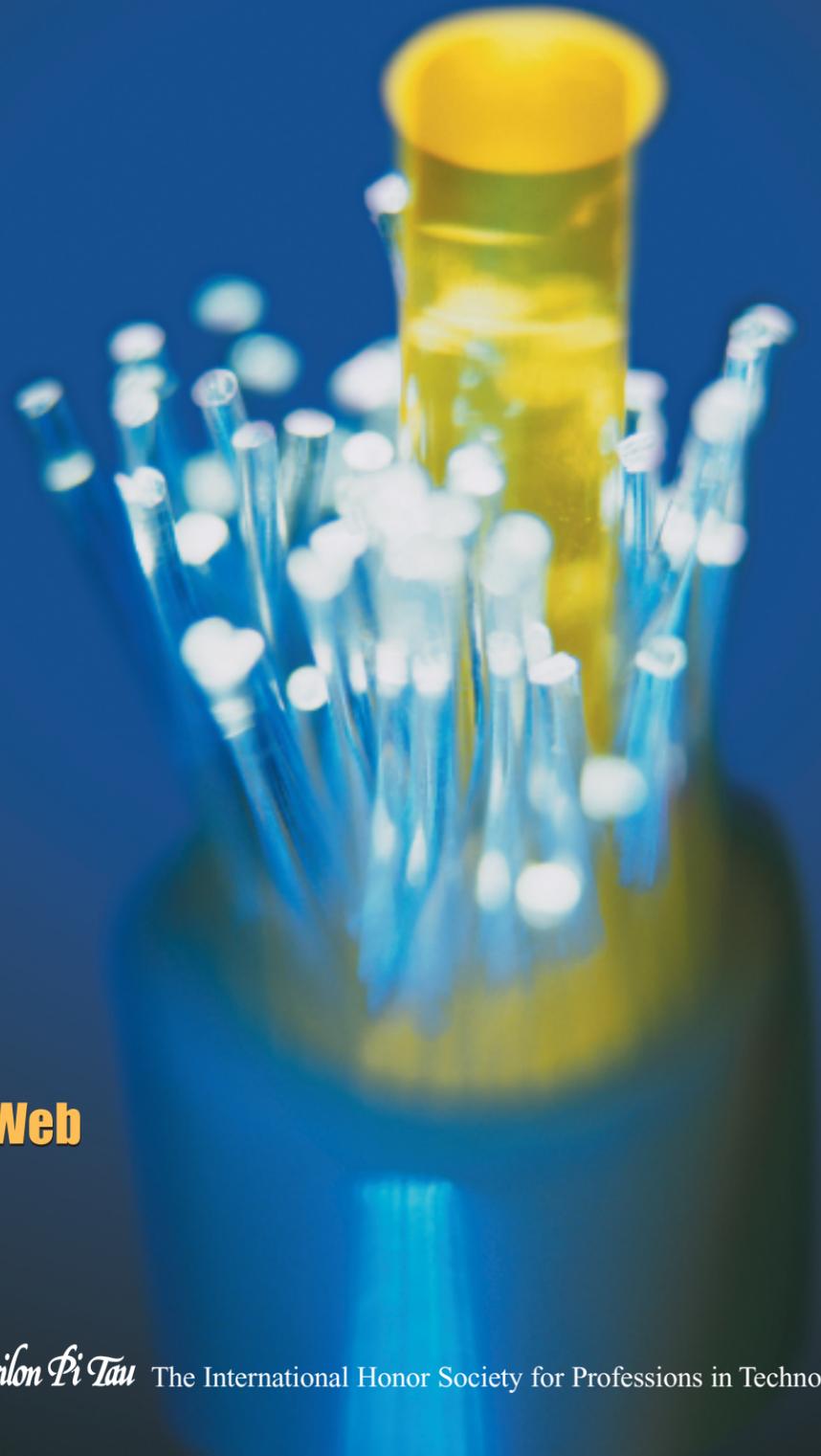


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# The Journal of **Technology** Studies



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# The Journal of Technology Studies

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## A New Editor

Jerry Streichler

Loyal readers will notice the change very quickly. It begins on the inside front cover and signals what this observer is pleased to define as an appropriate and timely reach for the next level.

The signs are good that the "next level" will be achieved because of the impressive talents, clearly supported by his credentials, of Dr. Dennis Cheek. With this issue, he phases in as co-editor of issue Number 2. The inside front cover changes and the Guidelines for Authors that are included in this volume prepare for his assumption of full editorial responsibilities for the 2004 issues and beyond. Editing the journal is one of the major responsibilities he undertakes and those were summarized in the last issue of *The Epsilon Pi Tau Preceptor* ("Dennis Cheek Accepts," 2003), parts of which are related here:

The Epsilon Pi Tau Board of Directors announced that Dr. Dennis W. Cheek accepted the appointment as Associate Executive Director for Information and Communication (I&C). The board has expressed great pleasure in welcoming a person with his extensive experience and qualifications to the leadership team, all of whom volunteer their services to Epsilon Pi Tau. The Associate Executive Director for Information and Communication is one of three Associates. The two others are: for Community and Technical Colleges, and for International Affairs. These three report to the Executive Director and, with him, comprise Epsilon Pi Tau's executive staff. . . .

The responsibilities of the position are critical to accomplishing the honor society's vision of superior member services and excellence in publications and communications. In that regard, Cheek will be responsible for the conduct of all of Epsilon Pi Tau's current I&C services and for developing and implementing revised or new I&C policies that will improve member services and other internal and external efforts. Currently, the primary I&C vehicles are *The Journal of Technology Studies*, *The Epsilon Pi Tau Preceptor*, and the honor society's web site. In time, Cheek may implement additional vehicles or modify existing ones.

Cheek has started his work on the

major project of implementing a new Epsilon Pi Tau web site for which templates and services will be provided by Affiniscape, a company that has extensive experience in providing web site services to organizations like Epsilon Pi Tau. In 2004 he will assume Editor responsibilities for *The Journal of Technology Studies* that he is already co-editing.

Only highlights of Cheek's much appreciated and valued experience can be communicated in this space.

Dr. Cheek is Vice President for Venture Philanthropy Innovations and Managing Director, Templeton Venture Philanthropy Associates, John Templeton Foundation in Radnor, Pennsylvania. He has 20 years of administrative and supervisory experience at school, district, state, national, and international levels. He has managed large assessment, curriculum development, teacher enhancement, accountability, and telecommunications projects, working with teachers, administrators, scientists, engineers, university faculty, corporations, and nonprofit organizations from across the sociopolitical spectrum. He has taught elementary through doctoral students in the U.S., Great Britain, and Germany over 25 years and conducted numerous preservice and in-service workshops in science, social studies, assessment, curriculum development, and science, technology & society studies. He has also served as an advisor to numerous federal and state agencies and task forces, scientific and technical associations, and consultant to educational publishers and corporations. As an author, contributor, or editor he has produced more than 475 publications and multimedia products in education, science & technology, the social sciences, and religion. He has served on the editorial or manuscript review boards of six journals and as a faculty or staff member at six colleges or universities. As part of these experiences he has been a contributor to successful grant proposals totaling more than \$30 million. His extensive travel program has taken him to 40 nations on four continents.

All this fosters a personal comment that it is a great boost to a predecessor's ego to be succeeded by a person with enormous energy, extraordinary accomplishments, and enviable talent and that it all bodes well for *The Journal of Technology Studies* and for Epsilon Pi Tau.  
JS

## References

Dennis Cheek accepts appointment to executive staff. (2003, Fall). *The Epsilon Pi Tau Preceptor*, 21(2), 13.



# Organizational Considerations for Advanced Manufacturing Technology

Bruce D. DeRuntz and Roger M. Turner

In the last several decades, the United States has experienced a decline in productivity (U.S. Bureau of Labor Statistics, 2001), while the world has seen a maturation of the global marketplace. Nations have moved manufacturing strategy and process technology issues to the top of management priority lists. The issues surrounding manufacturing technologies and their implementations have assumed greater importance in overall manufacturing strategy. Practitioners and researchers have developed strong interest in how advanced manufacturing technology (AMT) can be used as a competitive tool in the global economy to combat the phenomena of fragmented mass markets, shorter product life cycle, and increased demand for customization (Hottenstein & Casey, 1997). The combination of increased production flexibility and higher efficiency contradicts traditional manufacturing strategy. In traditional thinking, efficiency is possible only in the production of large volumes of standard products, while customization is associated with higher costs (Shepherd, McDermott, & Stock, 2000). Clearly, the impact of AMT is redefining the way multinational corporations are managing manufacturing operations; however, effective implementation of AMT has not occurred as rapidly as the development of technology due to organizational considerations. A measure of the global adoption of AMT is reflected in a research project called the International Manufacturing Strategy Survey, which received responses from 556 manufacturers in 18 countries and found that computer-aided design (CAD), material requirement planning (MRP), local area networks (LAN), and computer numerical control (CNC) machines are now the most popular AMTs used in manufacturing (Sun, 2000).

### Defining AMT

While the International Manufacturing Strategy Survey was explicit in identifying AMTs to the respondents, there has been some debate about whether AMT represents only the latest cutting edge technology or is it an adopted terminology that classifies a segment of manufacturing? The answer is the latter. AMT involves new manufacturing techniques and machines combined with information technology, microelectronics, and new organizational practices in the manufacturing process. AMT is

a key enabler to help manufacturers meet the productivity, quality, and cost reduction demands of competitive global markets (Industry Canada, 2002). Sun (2000) defined AMT as computer-aided technologies used in manufacturing companies. While Industry Canada's definition is comprehensive and Sun's definition is broad, both of these definitions are accurate in describing the integration of AMTs in the modern manufacturing system known as computer integrated manufacturing (CIM). The Society for Manufacturing Engineers (SME) developed one of the first models to illustrate the relationship of AMT to CIM (Goetsch, 1990). This original model contains one business component and four technical components. The four technical components are planning and controlling, information resource planning, product and process definition, and factory automation. Each of these components contain AMTs that can be classified by their level of integration (Bessant & Haywood, 1988) as illustrated in Table 1.

### Benefits of AMT

The benefits of AMT have been widely reported and can be classified as tangible and intangible. The tangible benefits, which are easily quantifiable, include inventory savings, less floor space, improved return on investment (ROI), and reduced unit costs. The intangible benefits, which are difficult to quantify, include an enhanced competitive advantage, increased flexibility, improved product quality, and quick response to customer demand (Ariss, Raghunathan, & Kunnathar, 2000). These benefits may still offer many other improvements with respect to organizational improvements and management/worker satisfaction. For example, the process of implementing AMT might lead to better communication, redesigned workflows, or better integration of work across functional boundaries.

Although operational and organizational benefits are often associated with AMT, all AMTs are not the same and do not provide the same benefits. It is known that innovations come in varying degrees of complexity and design. For example, some innovations are extensions to product offerings or improved processes (incremental), while radical innova-

Table 1. AMTs in the Four Components of a CIM System

Level of Integration	CIM Components and Their AMTs			
	Design and Engineering	Plan and Control	Information Management	Fabrication and Assembly
From standalone to integrated	CAD	MRP	LAN	NC/CNC
	CAE	MRPII	WAN	CAI/T/T
	CAPP		Shared DB	FMS/FAS
			CIM	APL/U
				ATC
				Robot
				AS/RS
				AGV

tions involve the development or application of new technologies into previously un-utilized applications. Innovations also involve changes in the core components without altering a product's overall architecture. Also, advancements can be made by linking together the existing technology and components in a new architecture (Noori, 1997). These individual characteristics of product change or process upgrade affect the level and type of benefits derived.

### Assessment and Planning of a Manufacturing System

The first step in planning for AMT generally occurs when an organization recognizes that current processes and procedures are inadequate to meet their current or future strategic needs. The usual response is to investigate current manufacturing processes and available technologies in an effort to accomplish the perceived needs or improvements. Implementing an appropriate new manufacturing system is, however, not a simple matter of purchasing and installing the technology. Great effort must be expended to ensure that the organizational framework is conducive to the successful adoption of such a system.

Innovative technology invariably leads to new relationships with an organization's external environment. Therefore, firms must evaluate the critical aspects of planning for modified relationships with its customers, system vendors, and materials/parts suppliers. One of the most crucial issues in planning for a new manufacturing system is justifying the investment in the new technology.

The prime motivation for installing AMT is to increase the competitiveness of the firm. Since different firms have varying competitive objectives, their expectations from AMT will also vary. Top management must therefore examine the firm's current competitive position

in relation to its desired position before deciding on particular technologies that appear to be suitable for its short-term and long-term goals. If it is seeking savings in human and capital costs, the natural choice will be the technology that promises cost efficiencies. If the expected benefits relate to improved product variety, then the technology that promises product flexibility will be preferred. In many instances, organizations have multiple objectives and the choice of technology should be based on that technology's ability to optimize the possibility of attaining both short-term and long-term objectives.

### The Role of AMT

The role of AMT can be broken down into three specific categories: operational, marketing, and strategic (Noori, 1997). In its operational role, AMT is often seen as an instrument for achieving economies of scale in small batch production. For mass production firms, the greater product flexibility provided by AMT could result in economies of scope. In its marketing role, AMT is viewed as providing the basis that enables firms to exploit competitive advantages fostered by the technology. In mass production firms, these are expected to gain a competitive edge through their ability to provide a wide range of products at their usual rates of efficiency. Small batch producers can enhance their process efficiencies while maintaining or improving product flexibility. The strategic role of AMT has been related to improving the firm's ability to cope with environmental uncertainty. It has also been viewed as an important factor in the overall improvement of industrial performance. Many believe that in order for AMT to play a strategic role, a philosophy that integrates the computing environment with the factory control system, the corporate planning system has to evolve.

Prime consideration should be given to the benefits that the firm expects to derive from the

implementation of the new technology. Only after this determination can an attempt be made to determine the type of technological innovation that will achieve these desired benefits.

It should be stated that not all types of products are conducive to automated manufacturing. Unlike software-based innovations, hardware-based innovations may be rather product/process dependent. For example, with reference to flexible manufacturing cells, there are those who assert that parts which have similar physical configurations or can be partitioned into distinct product families are prime candidates. This accounts for the proliferation of AMTs in metalworking and assembly. The continuing development of robotics is expected to lead to further development of these and other operations. Also, in spite of the increasing number of AMT adoptions, potential users should be cautioned against making premature decisions to adopt such systems because simple practices such as design for manufacturability may be just as effective and cost much less.

#### Technological Assessment

In order to understand a firm's technological competitiveness, a periodic technology assessment needs to be performed to chart the deterioration of technology and to benchmark a firm's relative position against a competitor. This entails the computation of the organization's "technology index" (a measure of the capability of the firm versus competitors' capabilities), and the comparison of this index with the state-of-the-art firm in the industry. When the firm's index deviates from the industry index by a pre-specified value, a signal indicating the need for technological improvement is triggered. The important factors of such an index should include set-up time, turn-around time, and minimum lot size as key components. Other considerations should be production flow, flexibility of manufacturing facilities and product lines, flexibility of production processes, interdependence of manufacturing segments, and continuity of production. In addition to technical components, the improvements in overall competitiveness and increased responsiveness to market changes should be highly regarded factors in the firm's technological index.

#### Management Commitment and Organizational Structure

No matter how great the planning or implementation of a process, management's commitment is probably the most key factor of all.

This commitment must not be restricted to the support of a concept. Management's commitment should look beyond the technical aspects of a project and to its organizational requirements for a successful implementation.

Training, team building, and the maintaining of employee morale should be seen as its underpinning. A commitment strategy to all personnel should analyze current tasks and skills, anticipate new activities, and determine the fit of skills needed to develop worker involvement or ability and also training programs for appropriate worker selection (Ghani & Jayabalan, 2000). A high level of management commitment should also facilitate the development of a workable strategy that helps eliminate organizational barriers to its implementation of worker delimitation at hierarchical levels and responsibility.

It appears that one of the major barriers to the successful implementation of a new technology is the existence of mechanistic organizational structures. This means that an organizational structure in an AMT firm should be more of an organic nature (Ghani & Jayabalan, 2000). Although the upper levels of management tend to delineate organizational goals based on strategic focus, the importance of a multiskilled workforce cannot be over emphasized. In many instances a reliance on multiskilled workforces and the continued commitment to design has allowed many manufacturers to adopt less complex and less expensive manufacturing techniques. A firm warning should be noted against the "technology first, organization later" approach; strong integration is highly needed. A firm that embraces modernization should first fit the skills of the available personnel into its modernization strategy, while gradually training to upgrade the skills of the employees (Ghani & Jayabalan, 2000).

#### Process Champion

A process champion is essential to a project success. Projects having a champion are more likely to proceed in an orderly fashion, achieve integration with the wider organization, and meet planned objectives. The roles of the process champion are seen as follows (Hottenstein & Casey, 1997):

1. Creative originator—the source of the idea (not necessarily but "figure head").
2. Entrepreneur—the person who adopts and sells the project.
3. Sponsor—protector and coach.

4. Project manager/overseer—the person who takes charge of planning.

There are also three areas of knowledge and skill required by a champion as shown in the following (Hottenstein & Casey, 1997):

1. Path finding—related to the ability to emphasize the necessity of technological change for future development.
2. Problem solving—related to technical knowledge concerning products and processes in combination with budgeting/planning/monitoring skills.
3. Implementing—requires interpersonal/communication skills.

Although these skills are essential, they are not necessarily sufficient to ensure successful implementation. An organizational structure that supports the work of the champion should be followed here (Hottenstein & Casey, 1997).

#### Changing Functional Relationships

The flexibility and efficiency obtained in successful AMT operations can lead to substantial strategic marketing advantages. Benefits such as increased market share, reduced prices, improved responsiveness to change in the marketplace, the ability to offer a continuous stream of customized products, faster product innovation, and improvement of the company's image have all been attributed to flexible AMT. New manufacturing technologies should offer many opportunities for innovative marketing strategies. It is believed that the adoption of automated technologies (FMS in particular) allows for a shift in the role of manufacturing from simply supporting marketing to playing a major role in strengthening a company's overall position in a particular market.

In order to take full advantage of the considerable manufacturing and marketing capabilities offered by new manufacturing technologies, there must be a balance between the marketing and manufacturing strategies of the firm. In instances where there are radical changes in manufacturing/process capabilities, innovative marketing strategies are essential. Rapid changes in marketing capabilities or market conditions usually will signal a need for manufacturing strategy changes. In an attempt to develop a shared marketing or manufacturing strategy, companies should determine appropriate order "winners" such as price, delivery, quality, and flexibility for their different markets and needs. For example, AMT with product flexi-

bility built in can relieve the pressure of an increased product diversity as well a fragmented market, while firms with both volume flexibility and mix flexibility incorporated into their AMT can respond better to the threat of unexpected competitors (McClenahan, 2000).

#### Functional Integration

In addition to facilitating the market or manufacturing interface, the improved process capabilities of an AMT organization can also affect other functional departments of the firm. Of particular relevance to manufacturing is the integration of design and R&D. It has been seen that in the past, the failure to remove organizational barriers between functional areas contributes to integration difficulties that are usually a departmental interfacing problem.

To provide a framework for functional integration, an organizational impact analysis must be completed. This seeks to analyze the importance of the functional departments and/or functions within each department. These usually arise from such analyses that determine the need for vertical or horizontal shifts (Ghani & Jayabalan, 2000), requirements for new departments or new positions within existing departments, changes in the organizational workflow, or required manpower changes in worker qualifications.

To encourage integration between separate functional departments, firms should promote the multifunctional team concept. Other methods to encourage integration include cross training, the formation of autonomous work teams, and the education of personnel in the interfacing departments (Hottenstein & Casey, 1997). The adoption of AMT creates a need for more complex relationships and greater integration within an organization's key environment. It is generally believed that complex projects can only succeed with a greater expenditure of effort in that the combined action of system vendors, consultants, and users are able to capitalize better on the full benefits.

#### System Vendors

The desired relationship between system vendors and users is a close collaboration over an extended period. Many analysts believe that adopters of such technology lack the technological knowledge to specify the most suitable system for their situation and to operate and maintain the system after installation. In cases where users lack technical knowledge, they have the choice of dealing directly with the vendors or

hiring a consultant for assistance. When the users prefer to deal directly with vendors, the vendors should be selected based on technical competence, quality, and dependability, rather than low cost. Users must also recognize that few vendors supply all the components required in any of the new manufacturing technologies and there will most certainly be networking problems in connecting equipment purchased from different suppliers. There will almost certainly be a software problem between the programs written by developers and the hardware to be purchased. Users must be aware that the system vendor will probably require detailed knowledge of business operations in order to design a system that meets the organization's needs. Unless potential users are prepared to provide such information, the solution offered by the vendor might not meet their requirements.

Given the complex nature of interfacing the hardware with the software developers, many potential users should use a consultant. It should be noted that in order for the user-consultant relationship to be beneficial, it is suggested that the consultant analyze the requirements and resources of the organization. The consultant should be allowed to make suggestions for the development of the internal structure as well as the structure of production to facilitate reduced start-up problems.

#### Customers and Suppliers

The adoption of AMT has direct implications for the relationship with customers in at least two areas. First, the adoption of AMT requires the firm to shift its manufacturing emphasis from a product orientation to a service orientation. This means that firms should foster tighter links with customers, with the emphasis being on achieving quick response to customer demand. To achieve this, customers should be allowed to participate in product development. Second, the adoption of AMT production should allow the manufacturer to reduce set-up time and produce in smaller lot sizes. Customer response to such capabilities might be to adopt a just-in-time (JIT) approach, thus increasing the number of orders.

As for the relation with suppliers, it is suggested that manufacturing firms work towards a relationship of interdependence with suppliers. Since an AMT is more conducive to JIT, it is believed that AMT users should encourage flexibility in their suppliers. This requires the sharing of sensitive data between producer and supplier (Brandt, 1998).

#### Economic and Strategic Benefits of AMT

The experience of plants adopting AMT indicates that major economic benefits of AMT include the following (Shepherd et al., 2000):

- Decreased lead times
- Reduced delivery times
- Reduced set-up costs
- Reduced set-up times
- Reduced transportation costs
- Reduced investment in stock
- Reduction in batch sizes
- Improved quality
- Improved reliability
- Improved dependability

Once the expected benefits are determined and the technology required to reap these benefits has been chosen, the firm needs to consider the economic justification for adopting such technology. The major considerations at this stage are the quantification of costs and benefits. While the costs are generally quantifiable, the benefits are often very difficult to quantify. In particular, while major strategic benefits such as early entry to market, perceived market leadership, and improved flexibility are extremely important for the growth and survival of the firm, they are not readily convertible into cash values or numbers. Organizations often seek to justify AMT adoption by showing that the number of people required to operate the production process will decrease. This practice might not be universally applicable due to the fact that the labor cost factor no longer constitutes a large part of manufacturing operations (Ariss et al., 2000).

#### Budgeting and Assessment Procedures

An issue in justifying investment in AMT has been the inappropriateness of the techniques of financial and accounting analysis in determining the tangible and intangible benefits that accrue from the adoption of AMT. The adoption of AMT usually depresses short-term profits. Since many AMT projects may take several years to install fully, there is a greater danger in setting only short-term financial goals. The payback period appears to be the main criterion used for the economic justification of such projects. A payback period of 1 to 5 years is the generally accepted amount of time to recover the cost of such projects. However, some eastern industrialized giants such as the Japanese use the payback method to serve more as a performance measure than as a rigid financial criterion.

The consensus with respect to accounting for AMT falls squarely on the side of adopting absorption costing, since it is widely accepted that the variable cost component will be reduced substantially while overhead costs rise. There are those who suggest that while firms may continue to use traditional factors in formal financial appraisal of their projects, these factors might not be the main objectives of that particular implementation (Ariss et al., 2000).

#### Summary and Conclusion

The key to successful AMT planning and implementation appears to be the choice of an appropriate manufacturing system and the attainment of an organizational infrastructure that will offer maximum support to the chosen system. To achieve the desired benefits from AMTs, marketing and manufacturing must work together to ensure that the marketing strategy reflects the manufacturing capabilities of the new technology. Closer working relationships

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among all other functions of the organization are also required if the firm is to achieve its innovation objectives.

Economic justification of AMT presents significant problems, since many of the touted benefits are difficult to quantify. However, in some instances strategic considerations may override pure financial considerations. This will allow projects with significant tangible and intangible benefits to overcome the rigid payback criterion that has caused the dismissal of many new manufacturing projects at the pre-installation phase.

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# 21st Century Manufacturing Supervisors and Their Historical Roots

Douglas R. Hotek

This article provides a perspective of the past and present roles of the manufacturing supervisor with a specific focus on new skills requirements.<sup>1</sup> Within the structure of manufacturing management, the supervisor plays a key role in implementing today's complex automated manufacturing technologies. The supervisor is at the bottom of the management pyramid—the one with upfront responsibility for machines, equipment, and tools, and for those who use them to produce a product. In the past, men who held the position were undisputed “bosses of the shop.” Today's companies refer to supervisors by different job titles, and although women make up a significant portion of the profession, it is not uncommon to hear employees refer to their supervisors as foremen (Walker & Guest, 1952; Walker, Guest, & Turner, 1956). Some refer to the position as *first-level* supervisor (Marcus & Segal, 1989). But the term team leader has recently come into use with the trend toward a teaming philosophy for workers.

Because many manufacturing firms use automation technologies in their competitive strategy (Skinner, 1996), production employees must know the meaning of the latest acronyms such as CAD-CAM, CIM, FMS, JIT, MRP/MRP II, SPC, SDWT, and TQM (defined later in this article), and they must be technologically literate in them. These complex requirements in employee-technology relationships have made an impact on the role of supervision. It has changed from that of directing and controlling employees to that of effectively leading the improvement of employee performance (Markland, Vickery, & Davis, 1998; Polakoff, 1990; Skinner, 1996; Stevenson, 1999).

This new leadership role for supervisors can best be understood in a historical context of evolving manufacturing technologies, workforce characteristics, and skills used. This is presented in two parts. The first is a historical perspective of the supervisor's job and how it has changed during the 20th century. The second section describes the supervisor's job in the context of modern-day complexities.

## Historical Perspective

In the early part of the 20th century, the Industrial Revolution was well on its way to creating a highly profitable system of mass production. Factories had become significantly larger in contrast to the relatively small job shops of the late 1800s. Production emphasized very large lot sizes. As opposed to single structures, most factories were made up of several buildings. The “American System” (Marcus & Segal, 1989, p. 72) of manufacturing now stressed precision and exactness in production so that parts could be interchanged easily during assembly. The early 20th century factories were characterized by large-scale production machine tools for such processes as sheet metal stamping, grinding, milling, and complex systems of organized mechanical assembly processes utilizing specialized jigs and fixtures. However, on the downside was the working environment. Many rotating shafts, pulleys, and belts used for drive mechanisms in these production machines of the early 20th century were fully exposed and in proximity to the worker who, by the way, was expected to work longer and harder than what is expected today. Worker fatigue and these types of dangerous conditions were undoubtedly a significant safety factor to be considered in those days (Khol & Mraz, 1997; Marcus & Segal, 1989; Williams, 1987).

At the turn of the century, the face of manufacturing in the United States was almost universally White and male. This was because highly skilled machinists and mechanics were initially needed to operate machinery and perform assembly processes. Minorities and women were hard-pressed to gain access to apprenticeships in these relatively high-paying jobs. However, industrialists such as Henry Ford and efficiency experts such as Frederick W. Taylor revamped ways in which production jobs were performed. Jobs that required highly skilled worker performance were simplified. Complex tasks were broken down into repetitively small sequential steps that could be documented and measured. These simpler tasks were then able to

be performed by lesser skilled workers (Marcus & Segal, 1989; Williams, 1987).

Some men who excelled at their jobs and mastered many different tasks were promoted to foremen (supervisors) with responsibilities for performing and overseeing the day-to-day production tasks on the shop floor. The early 20th century foreman was the undisputed boss of the shop, with considerable authority to make decisions regarding the work of his men. He was responsible for increased volume and capacity and lowered unit and labor costs. He was trained in the practice of *scientific management* (Taylor, 1947) to methodically measure, monitor, direct, and control the manufacturing system. However, to stimulate productivity in his workers and influence efficiency in the way in which materials flowed through his shop, he at times used supervisory methods that would be thought of as backward and abusive today. The supervisor of the early 20th century sometimes revived his tired workers with “stimulants furnished for each shift, such as a good belt of whiskey” (Grosson, 1998, p. 98). To punish and/or put fear into his insubordinates, he at times resorted to the use of threats and actual physical violence (Child & Partridge, 1982; National Industrial Conference Board, 1967; Patten, 1968). “So I hit him on the jaw. He knew who was boss now. He picked himself up and walked back to his job laying tracks” (Parker & Kleemeier, 1951, p. 1).

## Forces for Change

With corporate growth and prosperity, brought on by an accelerated Industrial Revolution, came a stronger push by workers to be ensured a better quality of work life. Workers united, forming bargaining units to help guarantee fair wages and better working conditions. The formation of these labor unions consequently transferred much of the factory foreman's authority up to higher levels of management. Disagreements concerning shop-floor issues escalated to the plant manager, who now controlled what was previously within the worker-supervisor relationship. Formalized negotiations, something for which the typical supervisor was not trained and therefore not capable of executing, became more technical in nature between corporate management and labor union representatives. Thus with unions an integral part of the manufacturing environment, some discretionary powers of the supervisor began to

wane. Prospective new-hires were now to be selected from the prescribed union list. All disciplinary actions, firings, suspensions, etc., had to follow the letter of the law as indicated in the union contract. Most company layoffs became controlled by union seniority and not by productivity standards. In addition, and what may have been most disheartening for the first-level supervisor, was that labor unions were now beginning to win major concessions in wage increases, job security, and working conditions—something the first-level supervisor had tried to do for years but had not succeeded in doing. These increased limitations on the first-level supervisor continued to refine and narrow the scope of the supervisor's job responsibilities (Kerr, Hill, & Broedling, 1986; Young, 1983).

The Great Depression and 1930s disappeared as manufacturing began working to support the efforts of World War II. In 1940, 28% of the machine tools in use were less than 10 years old. By 1945, 62% were less than 10 years old, the quickest advancement in capital investment known to have occurred in any developed country to this date. The rapid introduction of new technologies into manufacturing made World War II a different kind of war from its predecessor and was undoubtedly responsible for the outcome of that war. With research generated by defense needs, new machine tools were developed that could cut, shape, and form metal faster, with greater precision, and at lower cost. Materials and processes used in the assembly of auto and aerospace products continued to advance as well (Benes, 1998).

World War II likewise changed the face of the workforce of the middle 20th century. While men fought on the battlefield, women filled the millions of civilian and defense positions created as the United States shifted to wartime production. In 1942, women were recruited to work in the factories. “War gave women access to skilled higher-paying industrial jobs . . .” (Baxandall & Gordon, 1995, p. 245). As the war ended, most women gave up their wartime jobs to the men coming home from the war (Amott & Matthaei, 1991). Undoubtedly, the introduction of women in the workforce and the better educated, better organized worker home from the war left a lasting impact on supervisory practices in American industry (Fair, 1957).

By the middle of the century the job of the supervisor continued to be that of foreman, the overseer, director, and controller of employees. However, most training schemes for supervisors included considerable emphasis on human relations techniques, especially in the handling of women workers (Allen, 1957). Studies by Walker and Guest (1952) and by Walker et al. (1956) uncovered particular human relations skills in the successful supervisor. Their studies found that the best foremen were those who, in addition to directing and controlling shop operations, practiced good human relations with their wage employees. They treated employees as individuals, established personal relationships with employees apart from the job relationships, taught and promoted employees, acted as a shock absorber between employees and either the pressures implicit in the process or pressures coming from managers, stood up for employees in face of those pressures, consulted employees, and delegated responsibility to them.

World War II was the greatest factor in shaping the middle-of-the-century factory. The war's impact greatly affected developments in manufacturing technology, workforce characteristics, and supervisory methods. Technology developments resulted in newer, more precise, and more efficient machine tools. The workforce changed from predominantly male to predominantly female, and back again. With the introduction of working women and a war-experienced workforce, supervisors became more humanistic. They used less autocratic tactics of bullying and intimidating employees and showed more respect with a human relations perspective.

### Manufacturing Supervision Today

By the late 20th century, supervisory practices had evolved significantly and were largely influenced by changes in manufacturing technology, organizational strategy, and workforce characteristics. Yet, today's manufacturing organizations composed of advanced automation and unique workforce characteristics call for further reformation of supervision.

This section, first, focuses on new developments in the area of information technology. Second, examples of contemporary organizational changes are discussed. Then, the characteristics of the modern-day workforce are considered. Out of these flow a series of recommendations for practices of modern supervision.

### Manufacturing Systems and Information Technology

To be successful in today's complex work environments, most supervisors become technologically literate in many of the following.

*Computer-aided design (CAD)* is the use of computer software and hardware in interactive engineering drawing and storage of designs for manufacturing. Designers use CAD software to complete the layout, geometric dimensions, projections, rotations, magnifications, and cross-section views of a part and its relationship with other parts. The software allows designers to design, build, and test (in a virtual sense) production prototypes under given parameters as three-dimensional computerized objects. It compiles parts and quantity lists for a product, outlines fabrication and assembly procedures, and transmits the final design directly to production machinery such as milling and rolling machines (Goetsch, 1992; Markert, 1997; Markland et al., 1998; Stevenson, 1999; Turban, McLean, & Wetherbe, 1996).

*Computer-aided manufacturing (CAM)* software uses the digital output from a CAD system to directly control programs in production equipment such as robotics and numerical control machining centers. When CAD is feeding information to CAM, the combined system is referred to as CAD-CAM. CAD-CAM encompasses the computer-aided techniques that facilitate planning, operation, and control of a manufacturing facility. Such techniques include computer-aided process planning, computer-generated work drawings and standards, MRP II, capacity requirements planning, and shop floor control that are direct responsibilities of the supervisor (Goetsch, 1992; Markert, 1997; Markland et al., 1998; Stevenson, 1999; Turban et al., 1996).

*Computer-integrated manufacturing (CIM)* is a term that originated in the 1960s, a concept in American industry that encompasses a diverse collection of manufacturing technologies in use today and implies a system where all components necessary for production of the product are integrated. This includes the initial stages of planning and design through the stages of purchasing, production, packaging, shipping, and order fulfillment. CIM is not a specific hard technology per se. It is more of a management technology that involves strategic efforts to combine all available technologies such as

CAD-CAM, MRP/MRP II, JIT, and other automated systems to manage and control an entire enterprise (Markert, 1997). If another factor were to be included, it would relate to the human elements between supervisor and wage employees. According to Markland et al. (1998), "many implementations of new technology, including CIM have failed because responsible parties (such as supervisors) failed to prepare the workforce to accept, support, and be able to use the new technology" (p. 322).

*Flexible manufacturing systems (FMS)* are fully automated, computer-controlled manufacturing systems that offer substantial advantages in comparison to a conventional job shop. An FMS is a set of machines linked by an automated materials handling system—all under central computer control. Flexible machining centers (called cells) can produce a variety (or family) of parts with a simple change of software. Instead of using special-purpose machines and tooling to perform a single operation, FMS may use computerized machines that can be quickly reprogrammed to do a variety of things, which could be from machining several different types of product to performing multiple operations on a single piece of work. This is especially important for manufacturing small lot sizes of products and those that undergo rapid changes in specifications (Markert, 1997; Volti, 2001).

*Materials requirements planning (MRP)* is a calculation technique that deals with production inventories and scheduling. It is used for planning future manufacturing lots and purchase orders according to what is required to complete a master production schedule. MRP provides the benefit of accurately forecasting the demand for like items in different products that are interdependent, which is generally the case in a just-in-time manufacturing system. For instance, a company may make three types of widgets that all use the same type of screws, bolts, and nuts. Thus, the demand for the bolts, for example, depends on the shipment schedule of all three types of widgets. MRP is typically computerized because of complex interrelationships between products and their subparts, and the often need to change plans when delivery dates or order quantities are changed (Markert, 1997; Turban et al., 1996).

*Manufacturing resource planning (MRP II)* is an application software arrangement used by the line organization. Essentially, MRP II cre-

ates a closed-loop management system that integrates the regular MRP with all other major functional areas of the organization such as forecasting and sales, design engineering, purchasing and receiving, production activity planning and maintenance, and distribution planning and cost accounting. Furthermore, it coordinates activities toward the goals of a JIT system, producing the right product at the right time (Markert, 1997; Turban et al., 1996).

*Statistical process control (SPC)* is a quality-control method that provides information helpful in the reduction of defective parts or products by statistically monitoring manufacturing processes, typically through the use of computerized charts and graphs. To manufacture products within specifications, processes producing the parts need to be stable and predictable. A process is considered to be under control when SPC charts show that variability from one product to the other is stable and predictable. If and when a process becomes unstable and about to go out of control, SPC charts will show evidence of such in far enough time so that adjustments can be made to the process before defects are produced (Deming, 1994; Grant & Leavenworth, 1988; Juran, 1988).

### Organizational Changes

Changes in the manufacturing environment and in technology induce organizations to change the manner in which they operate. It has long been recognized that there are strong relationships among the environment, technology, and organizational structure. The following are examples of organizational changes that also call for reformation of first-level supervision.

*Total quality management (TQM)* is an integrative management approach that emphasizes continuous process and system improvement as a means to achieve customer satisfaction and long-term company success. Simply stated, TQM utilizes the strengths and expertise of everyone in the company as well as scientific methods for problem analysis and decision making. Quality is the concern and responsibility for everyone in the organization and is built into every product and business process. TQM is based on the premise that customers (internal, external, or both) are the focus of all activities of an organization, and relies on all members of the organization to continuously improve everything they make and do as well as the culture in which they work. Most important, TQM is a philosophy for

long-term, never-ending commitment to improvement, not a temporary program (Ahire, Landeros, & Golhar, 1995; Deming, 1994; Summers, 1997).

*Just-in-time* (JIT) is a complete inventory control and production scheduling system that attempts to reduce costs and improve work flow by scheduling parts and materials to arrive at a manufacturing work station precisely at a time when they are needed. Such a system saves space, reduces inventories, and minimizes waste, and by doing so saves considerable capital. JIT utilizes a pull system for moving goods (where control of materials and parts movement is established in reverse of the work flow, from the last work station to previous stations) and several other technologies and management techniques that enable production to move as fast as possible without disruption. The major components of a JIT system are few but reliable suppliers, small lot sizes, low inventories, high-quality materials, fixed production rates and standardized outputs, extensive preventive maintenance and quick repairs, quick machine setups, and moderately utilized capacity. Perhaps the most significant elements to a successful JIT system are multiskilled employees and participative supervision that encourage continuous innovation and improvements (Markland et al., 1998; Stevenson, 1999; Turban et al., 1996).

*Self-directed work teams* (SDWTs) are a functional group of employees (usually between 8 and 15 members) who share responsibilities for a particular unit of production. Technically, the team consists of individuals who are trained, empowered (with authority), and held accountable to make decisions regarding the quality, cost, and scheduling requirements of their production unit and for the safety of their production processes (Torres & Spiegel, 1990). Each member of a SDWT possesses a variety of technical skills and is encouraged to develop new ones to increase the job flexibility and value of the SDWT (R. Koenig, R. Schnack, & R. Marconi, personal communication with respective vice president of operations, director of manufacturing, and production manager, Norand Corporation, Cedar Rapids, IA, August 10, 1995).

#### Workforce Characteristics

Changes in the characteristics of today's workforce obviously affect the job of the super-

visor. According to Rue and Byars (1996), one of the more prevalent changes in today's workforce that affect the supervisor's job is the transformation of its demographics. The following are examples of this phenomenon.

Compared to the 1980s, Kutcher (1991) predicted that the workforce in the 2000s would grow more slowly. Gendell and Siegel (1992) expected older members of the workforce to take early retirement. In contrast, Redwood (1990) stated that women—especially women under 40—would enter the workforce at an accelerated rate. A recent report by the U.S. Department of Labor (1999) validates these forecasts. The report shows that women are working more while men are working less. What is most characteristic of the shrinking workforce is the age of workers. Although young people are a substantial part of the workforce, there is a disproportionate amount of wage employees under age 35. At the lowest age levels this reduction is already upon us. Overall, wage employees are getting much older very rapidly. Thus, there are fewer qualified people to fill wage employee positions, the type of condition that can make for a labor shortage.

The U.S. Department of Labor (1999) also reported that minority groups of all types are becoming a larger proportion of the workforce. In fact, due to a need for skilled labor, immigration plays the largest role in the growth of the United States. Some state governments (Workforce Resource Bureau, 2001) are preparing to reverse their trend of a declining workforce population. They see great potential in attracting immigrants and refugees from Hispanic and/or Latino countries of origin and have set strategic planning goals to welcome and accommodate these newcomers (Iowa Governor's Strategic Planning Council, 2000). As a result, in the year 2000, the U.S. Bureau of the Census counted 82,473 Hispanic and/or Latino residents in Iowa, which is a 152.6% increase from a 1990 count of 32,647 residents from the same countries of origin (Iowa State University, 2001). Certainly, the supervisor plays a positive role for those immigrants who choose employment in the manufacturing sector, especially in the challenge of leading non-English-speaking workers and/or those with poor English language skills.

Perhaps the most significant change in the shape of the workforce is that workers are now

expected to fulfill jobs that require more than a high school education (Carnevale, 1991; Redwood, 1990; U.S. Department of Labor, 1999). In today's world of manufacturing, unlike other sectors in the economy, the work of wage employees is becoming increasingly complex as they find themselves having to continuously upgrade their skills to fit the latest manufacturing technologies (Carnevale, 1991; Dean, Dean, & Rebalsky, 1996). For example, compared to their day-to-day operations of the past, employees are now using less manual skills and more intellectual skills as required for operating automated machinery and processes. Their skills have also become more versatile in the variety of manufacturing technologies they apply (Markland et al., 1998; Stevenson, 1999). According to Carnevale (1991), Douglas (1997), and Gupta and Ash (1994), employees are being told less by their supervisors of what to do, as well as when, where, and how to do it, and are expected to autonomously make more decisions as members of self-directed work teams. Researchers agree with two of Deming's (1994) long-standing opinions regarding trends in employee performance: (a) Performance outcomes are being greatly influenced in breadth and depth by increased sophistication of manufacturing and organizational systems, and (b) employees are being empowered to make less reactive and more proactive job-related decisions.

Even in the modern age of automation, the highly diverse, highly skilled, highly motivated, productive employee is still manufacturing's greatest asset. The person best able to make the most efficient and effective use of this asset is the well-trained, knowledgeable supervisor.

#### Supervisor Characteristics

Historically, supervision has been viewed as a process concerned with accomplishing work through other people, and this concept is still valid. If asked what it is that a supervisor actually does today, most people would still probably respond with an answer that implies that a supervisor oversees the work of wage employees (Berliner, 1979; Deming, 1994; Drucker, 1993). It has been well established that an important skill of a supervisor is to appraise and improve the performance of his or her employees. However, manufacturing has become so technology dependent that the impact of technology on productivity and on employees cannot be ignored. Supervisors are still responsible for

ensuring that employees accomplish their work. Yet, more and more employees are using technology to do their work, and technology is becoming increasingly sophisticated and increasingly complex. In a symbiotic relationship, the employee depends on technology and technology depends on the employee (Dean, 1995; Rothwell, 1996; Rummler & Brache, 1995).

Supervisors must be able to bring out the best from both employee and technology, and learn to make optimum use of the employee-technology relationship. To do so supervisors must understand technology as a concept, be familiar with the latest developments in manufacturing technology, appreciate the impact of technology on the employee's work, be familiar with employee-technology relationship problems and know how to deal with them, and be prepared to deal with the rapid and continual changes associated with modern manufacturing technology (Goetsch, 1992; Petersen, 1989). In short, the modern supervisor should be a technically oriented team coach (Deeprise, 1995).

#### Research Gaps

We know what the human resource, academic, and management authors think supervisors should do. However, what is missing from most of the extant literature is perspective of the line organization—what *they* think supervisors should actually be doing on the production floor. Ahire et al. (1995), Crutchfield (1998), and Douglas (1997) implied that further research is needed in identifying the leadership elements required of supervisors and their roles and responsibilities in a highly technical and complex manufacturing organization. With respect to the job of supervisor in today's work team environment, Gupta and Ash (1994) stated:

Although many operators and mechanics welcomed the promise of input into the plant's work, lower level supervisors felt extremely threatened by the changes. Of all the employees at [the company], these supervisors are experiencing the most uncertainty about the effect the work teams would have on their work and livelihood. They were told their jobs would change drastically, but no one seemed able to articulate how. (p. 198)

Skinner (1996), referring to supervision of highly skilled employees and the use of modern manufacturing technologies as a competitive

One conclusion seems clear: we are now in a totally new industrial era in which the performance required for competitive success is orders of magnitude greater than in the past. But in the face of these heightened requirements, hard-pressed production managers appear to be trying for competitive parity principally by concentrating on adopting the latest tactical controls and planning techniques . . . [but] . . . typical industrial managers do not seem to know what to do differently . . . the urgent need [is] to improve performance. (p. 16)

There are many textbooks and other literature on what seems to make the modern supervisor a good supervisor, and most agree that the supervisor plays a key role in managing today's manufacturing operations. However, there is very little sound research in what people in the line organization believe supervisors actually do that is most important.

The evolutionary role of the manufacturing supervisor has gone from autocratic boss to human relations overseer to technical team coach. Now, when employee performance must be enhanced to accommodate organizational changes and ever-increasing sophisticated manufacturing technologies, supervisors need to do more than simply train their employees. If supervisors knew *everything* about today's complex organizational systems and automated manufacturing technologies, they could tell their employees what to do, how to do it, and when to do it. They could get by with the traditional supervisory

skills of bossing and controlling employees, making all of the decisions. But when supervising a diverse group of self-directed and well-educated employees who are highly skilled in modern manufacturing technologies, such an approach would be a mistake. Hence, there is a declining need for directive supervision.

However, contrary to a vision of factories run by robots, successful manufacturing systems today depend more than ever on the skills of the first-level supervisor. An increase in breadth and depth of employee performance both on the factory floor and in business decision making has called for a transformation of skills used by supervisors. Studies by Crutchfield (1998), Douglas (1997), and Hynds (1997) show that in order for supervisors to make the transformation, from that of directing and controlling employees to that of leading and improving employee performance, it is important for them to obtain unique leadership skills. Many believe the primary skills of a supervisor today are in managing what Rummler and Brache (1995) referred to as the "human performance system" (p. 71). Supervisors need skills in applying *performance technology* (Hotek & White, 1999), a more complete and continuous approach to improving the system in which they and their employees work.

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## Notes

<sup>1</sup> Because I focus on the skills of the supervisor that are changing, more traditional skills that fall in the category of people skills and business skills are not given much attention. However, these skills are still integral and necessary for effective supervision.



## The Three Gorges Dam of China: Technology to Bridge Two Centuries

Wafeek S. Wahby

Some of the most sophisticated 20th-century technologies have been applied to build the largest hydroelectric dam in the world, the Three Gorges Dam Project (TGDP) of China. The author administered a study abroad course in China from May 27 to June 10, 2000, to study the massive project as it approached the halfway mark of its second and most critical stage, namely Phase II. This article sheds some light on this sizable project and summarizes information and observations gathered first-hand during this study abroad course on the construction of the Three Gorges Dam (Wahby, 2000).

As students, teachers, and other practitioners in the various technology professions read this article, it is hoped that they may get a better understanding of this substantial project, its main components, and the challenges that faced and still are facing its construction, as well as the technologies used to complete it. It is also hoped that the readers may see the tremendous effects of this massive undertaking on different aspects, on China as well as on the rest of the world. Those aspects include but are not limited to water conservancy, hydroelectric power generation, environment, ecology, geology, geography, economy, politics, transportation, society, culture, business, industry, and even technology itself.

In particular, technology is being challenged and stretched to the limit as never before to construct the Three Gorges Dam. Unprecedented production rates are becoming the norm in order to keep the sizable project on schedule, while adhering to the highest quality requirements of construction codes. After the completion of the project by 2009, the technology used in the construction of the dam will probably need to be reviewed and enhanced in light of lessons learned.

In addition to a description of the main components of the project and the phases of its construction, a historical background and a timeline of the events that culminated in China's decision to build this dam are presented in this article. The article also points out the reasons why this sizable project is being built and dis-

cusses the results that are anticipated after its completion. Some of the challenges faced in the construction of the project are analyzed, together with how they were dealt with.

### Background

The TGDP is projected to become the world's largest dam—nearly four times larger than Hoover Dam, with a height of 607 ft (185 m) and a length of approximately 1.4 miles (2.3 km; Kosowatz, 1999). The TGDP is composed of the dam, two power plants, and the navigation facilities. The dam is composed of three sections: the spillway dam, the intake dam, and the non-overflow dam. The permanent navigation structures include a ship lock and a ship lift. A temporary ship lock is also a part of the project that is being used during Phase II of the TGDP.

### TGDP Location

The Three Gorges is one of the world's most famous scenic sites around Qutang, Wuxian, and Xiling gorges. The TGDP is located almost 750 miles (1,200 km) south of Beijing and 650 miles (1,000 km) west of Shanghai, China. More specifically, the TGDP is being constructed in Sandouping Village, Yichang County, Hubei Province, in the Xiling Gorge, about 25 miles (40 km) upstream from the existing Gezhouba Project located at Yichang City.

### TGDP Site

The site for the TGDP was selected at Sandouping, along the Yangtze River, after about 15 other sites were studied. The site has many advantages. The crystalline rock, intact granite with 100 MPa of compressive strength, forms a good foundation bed for the dam. In addition, there are no major unfavorable or injurious geologic structures in the vicinity of about 9 miles (15 km) around the dam site, while the regional seismic activities are small in intensity, low in frequency.

Interestingly, the river valley at the construction site of the TGDP is relatively open and broad, with the hills on both sides of the river fairly flat, providing for a good-size lake right at the upstream of the dam. Also, the existence

of the small islet of Zhongbaodao near the right-hand side bank of the Yangtze River was favorable for the river diversion project.

## TGDP Main Hydraulic Structures

### 1. The Dam

The 60-story high dam is a concrete gravity type that is composed of three sections: the spillway dam, the intake dam, and the non-overflow dam. The total length of the dam axis is 1.45 miles (2.31 km), with the crest elevation at 615 ft (185 m) and a maximum height of 607 ft (181 m), 650 ft thick at the base, and 50 ft at the crest. By comparison, the Hoover Dam in the United States is 0.24 mile (1,244 ft) long, 727 ft high, 660 ft thick at the base, and 45 ft thick at the crest.

The spillway dam, located in the middle of the river course, is 0.3 mile (483 m) long in total, where there are 23 bottom outlets and 22 surface sluice gates. The dimensions of the bottom outlets are 23 x 30 ft (7 x 9 m), with the elevation of the inlets at 300 ft (90 m). The net width of the surface sluice gates is 27 ft (8 m), with its sill elevation at 525 ft (158 m).

On both sides of the spillway dam section there are the intake dam and non-overflow dam sections. With a maximum discharge capacity of 102,500 m<sup>3</sup>/s - (one m<sup>3</sup> = 35.32 ft<sup>3</sup>) at the pool level 600 ft (180.4 m), the project is able to discharge the possible maximum flood (PMF) and is capable of producing 847 TW.h of electricity output annually.

### 2. Power Stations

Two powerhouses will be placed at the toe of the dam, one to the left and another to the right. The total length of the powerhouse on the left is 0.4 mile (0.65 km), with 14 sets of hydro turbine generator units installed. The total length of the powerhouse on the right is 0.37 mile (0.6 km), with 12 hydro turbine generator units installed. Those 26 sets of hydro turbine generator units (Francis type, 700 MW each), totaling 18,200 MW of installed capacity, will produce 847 TW.h of electricity output annually—exceeding that of the largest dam currently in operation by almost 40%. There are 15 transmission lines, with 500 kV AC lines to central China and Chongqing City and about 500 kV DC lines to east China.

Meanwhile, enough room has been preserved on the right bank for a future under-

ground powerhouse with an extra six hydro turbine generator units totaling 4,200 MW of installed capacity. The intakes of these units are being constructed simultaneously with the project. The hydroelectric power generated by the TGDP would replace 40 to 50 million tons of raw coal combustion each year. This reliable, cheap, and renewable energy is expected to play a very important role in the development of China's economy and the prevention of environmental pollution.

To put this in perspective, China's total power capacity in 1990 reached about 130 million kilowatts (Tillou & Honda, 1997). To keep pace with China's economic growth, with annual increases in the gross national product estimated at 6%, its power output must rise by 8% annually to reach about 580 million by the year 2015. Given that almost three quarters of China's energy comes from coal, this growing coal consumption poses a huge threat to the environment. Coal burning emits several harmful air pollutants, including carbon dioxide (CO<sub>2</sub>)—a major contributor to the greenhouse effect and global warming. China used between 1.1 and 1.2 billion tons of coal in 1993, mostly for heating and generating electricity. Industry sources predict that China will consume as much as 3 to 4 billion tons by the year 2009. Sulfur dioxide emissions, which cause acid rain, are expected to rise from 15.5 million tons in 1991 to 2.5 billion tons by 2009.

### 3. Navigation Facilities

The permanent navigation structures consist of the permanent ship lock and a ship lift. The design capacity of annual one-way navigation is 50 million tons. The ship lock is designed as a double-way, five-step flight lock carved from granite on the river's left bank and lined with concrete; each lock chamber is dimensioned at 930 x 113 x 17 ft (280 x 34 x 5 m)—length x width x minimum water depth—capable of lifting 10,000 tons of barge fleet 285 ft, making it the largest such system in the world.

The ship lift is designed as a one-stage vertical hoisting type with a ship container sized 400 x 60 x 11.7 ft (120 x 18 x 3.5 m), capable of carrying one 3,000 ton passenger or cargo boat each time. In addition, one temporary ship lock is designed for use during the construction period with an effective chamber size of 800 x 80 x 13.3 ft (240 x 24 x 4 m).

## TGDP Reservoir

The TGDP is the largest water conservancy project ever built in the world. The TGDP will completely block the Yangtze River course to impound a narrow, ribbon-like reservoir. This ribbon- or river-like, rather than a lake-like, reservoir will have a total length of over 400 miles (600 km)—longer than Lake Superior—and an average width of 0.7 miles (1.10 km)—less than twice the width of the natural river channel.

The total water catchment area is about one million km<sup>2</sup>. The surface area of the reservoir will reach 1,084 km<sup>2</sup>, and the land area to be inundated will be 632 km<sup>2</sup>—almost twice the original water surface area. The average annual runoff is 451 billion m<sup>3</sup> and 526 million tons of annual sediment discharge. With the normal pool level (NPL) at 570 ft (175 m) above sea level, the total storage capacity of the reservoir is 39.3 billion m<sup>3</sup>.

## TGDP Dateline

Following is the TGDP dateline (Export-Import Bank of the United States, 1996):

- 1919 Dr. Sun Yat-sen proposes the original flood control dam.
- 1920 Preliminary studies and site investigations.
- 1954 Huge flood; all transportation stopped for 100 days.
- 1958 Chairman Mao proposes new plan.
- 1970 Compromise of the Gezhouba Dam to see whether it could be a substitute for the Three Gorges Dam.
- 1980 Gezhouba Dam completed and proves not to be a substitute for the TGDP.
- 1983 Yangtze Valley Planning Commission completes feasibility study of the Three Gorges Dam.
- 1985 U.S. working group formed and Canadian International Development Agency finances feasibility study.
- 1989 Canadian International Development Agency (CIDA) determines project is technically, environmentally, and economically feasible.
- 1990 Premier Li Peng revives the project in the aftermath of Tiananmen Square.
- 1991 U.S. Bureau of Reclamation signs contract to give technical support.
- 1992 End of the 40-plus-year verification phase, and the commencement of implementation phase. Chinese Congress

votes on project (1,700 votes total): 1,100 for (64%), 400 against (24%), 200 abstained (12%).

- 1993 Former U.S. and Canadian support withdrawn. In their campaigns against the dam, International Rivers Network (IRN) and a coalition of US environment, development, and human rights groups encourage the U.S. administration to withhold financial support for the U.S. companies eager to bid for the project due to its adverse environmental and social impacts.
- 1993 First batch of construction teams enter into the dam site, starting the construction for the preparatory works and first-stage diversion works.
- 1994 (December 14) Formal start of the TGDP's construction at the dam site.
- 1997 (November 8) End of Phase I, Cofferdam completed, Yangtze River diverted, and ships sail through channel, start of second-stage construction.
- 1998 Huge flood caused by the Yangtze River, interrupting construction work of the Three Gorges Dam and affecting 300 million people, with death toll 300,000 people and US\$30 billion estimated losses. This monetary loss of a single flood makes the Chinese government even more determined to complete the project, seeing that its overall cost (US\$27 billion) is even less than this single loss.
- 2000 Phase II underway. Scheduled to be completed 2003.
- 2003 Scheduled end of Phase II and start of Phase III.
- 2009 Scheduled end of Phase III and completion of the TGDP.

## TGDP Construction Phases

The total duration of construction is projected to be 17 years, divided into three phases:

- 1993-1997: First phase construction, including preparation period, dominated by massive earthmoving. Its completion was signaled by the damming of the Yangtze River on November 8 and the opening of the diversion channel.
- 1998-2003: Second phase construction, will be completed when the first

generating unit in the left-bank power plant goes on line and the permanent ship lock begins operation.

- 2003-2009: Third phase (final) construction, marked by the completion of all 26 electricity-producing turbo-generators.

### TGDP Quantities of Construction Work

The main work quantities to be done in the construction for principal structures and diversion works are as follows (China Yangtze Three Gorges Dam Project Development Corporation, 1999):

- Earth-and-rock excavation  
102.83 million m<sup>3</sup>
- Earth-and-rock embankment  
31.98 million m<sup>3</sup>
- Concrete placing  
27.94 million m<sup>3</sup>
- Re-bar  
463.0 x 10<sup>3</sup> tons
- Metal works  
256.5 x 10<sup>3</sup> tons
- Installation of hydro turbine generator  
26 sets (18,200 MW)

### TGDP Cost

In 1990, the cost of the project was estimated at US\$12 billion (Y90.09 billion). A more recent estimate is \$27 billion (Y223 billion). Nearly half of the project's cost is being applied to the resettlement of hundreds of villages and towns along the river's edge. If the estimated cost is increased by a factor of 2.25 within 10 years, it might well be possible that the actual cost by the end of the project would reach the \$50 billion mark—more than virtually any other single construction project in history.

### TGDP Controversy

The construction of China's Three Gorges Dam, the largest dam in history, is already in its ninth year and is expected to be completed by 2009 with a cost currently estimated at over \$27 billion. Perhaps more than any other project in the history of China, the TGDP has attracted the attention of many individuals and groups in China, as well as worldwide, and created much controversy, particularly among the experts, due to its almost equally compelling advantages and disadvantages. Supporters of the project believe that the advantages of the project far outweigh the disadvantages, and, obviously, this is the view of the decision makers in the Chinese government because the project is indeed moving

forward. Following is a list of both the advantages and disadvantages for the readers to think and decide for themselves:

### TGDP Advantages

1. **Flood Control:** The TGDP is projected to allow a precise control over the Yangtze River, reducing the severity of flooding by 90%, thereby saving life and property from destruction.
2. **Power Generation:** With its 26 turbines at full capacity, the TGDP is estimated to generate 18,200 MW annually, making it the biggest hydropower producer in the world. This would provide 15% of China's electricity—mostly in the Yangtze River basin area. That output is equivalent to approximately 50 million tons of coal or that of 18 nuclear power plants, producing 84 billion kilow.hrs output per year.
3. **Navigation Improvement:** The TGDP is projected to allow the passage of 10,000-ton ships to Chongqing instead of the limited 5,000-ton ships, increasing the annual one-way navigation capacity from the present 10 million tons to 50 million tons, meanwhile decreasing the navigation cost by 35% to 37%. With almost 15 million people, Chongqing will become the largest "seaport" in the world.
4. **Other:** The project is expected to promote the development of fishery in the reservoir, as well as tourism and recreational activities. To a certain extent, it should improve the water quality of the middle and lower reaches of the river during the dry season and create favorable conditions for the south-to-north water transfer projects.

### TGDP Disadvantages

1. The reservoir will flood 13 cities, 140 towns, 1,352 villages, and 657 factories—a great economical, sociological, and cultural irreversible loss—and will create a pollution problem when the infrastructure of these communities become submerged under water.
2. Construction will force the resettlement of almost two million people, cutting them from their roots and creating all kinds of social instability associated with a "river refugee new community."

3. The reservoir will flood approximately 75,000 acres of the best agricultural and cultivated farmland in the region, requiring farmers to start cultivating lesser quality lands.
4. Over 110 sites of cultural and historical importance will be forever lost.
5. It is feared that the project will alter the entire ecological system and adversely affect the environment in the area. Not only will it obstruct the river's natural course, but it will also inundate hundreds of acres of land that are the habitat for many species.
6. It is predicted that the devastating environmental damage induced by the project will also threaten the river's wildlife. In addition to massive fish species, it will also affect endangered species, including the Yangtze dolphin, the Chinese sturgeon, the Chinese tiger, the Chinese alligator, the Siberian crane, and the giant panda.
7. Chongqing and many other cities along the river will flush tremendous amounts of sewage and toxic waste into the reservoir, turning it into a "cesspool" that will threaten the health of the scores of millions who live in the Yangtze basin, while no funds have been allocated for water treatment ("China's Three Gorges Dam," 1996).
8. Pollution and slow-moving water could also threaten fish, reptiles, and other wildlife that depend on the river for their survival. Almost 80 species of fish, Yangtze dolphin, finless porpoise, Chinese sturgeon, and giant panda will be endangered ("China's Three Gorges Dam," 1996).
9. Downstream regions would be deprived of the fertile silt traditionally carried by the Yangtze River as it becomes trapped behind the dam. As silt accumulates upstream, it would affect Chongqing because the water level would rise at the reservoir's opposite end and submerge parts of it. This also could cause imbalance in the overburden pressure on soil strata, which may increase the risk of earthquakes and landslides, and eventually threaten the dam's stability.
10. Navigation benefits are exaggerated

because heavy sediment buildup in the reservoir is likely to continue to hinder navigation.

11. Flood control benefits are overstated; the reservoirs could at best store only a fraction of the floodwaters entering the Yangtze during a peak-flow year.
12. Dam construction will divert funds from more beneficial, less risky projects such as constructing smaller scale dams along the Yangtze and building new canals or branches that may work as safety outlets when the Yangtze floods attack, which also brings water to new areas.
13. The dam would be a military target, creating a possible disaster area should it fall due to an attack or due to earthquakes or natural catastrophes.
14. The dam and the reservoir will destroy some of China's finest scenery and an important source of tourism revenue.

### TGDP Status Highlights

The second of the three construction phases of the TGDP is already halfway completed. This critical stage presents perhaps the TGDP's biggest challenge: keeping to an aggressively ambitious schedule while constructing—according to the highest technical specifications and foreign inspection—the permanent five-story ship lock, the dam's spillway, and left intake structure, which will house 14 giant turbines. The schedule calls for the first two turbine generators to be producing power—and critical revenue—followed by the remainder of the bank in 2003. This means breaking every known record for concrete construction (Wahby, 2000).

To meet deadlines, over 25,000 workers must pour concrete at a pace of about 520,000 cubic yards (400,000 cubic meters) per month, requiring an extensive and complex system for transporting enormous quantities of concrete from the mixing plants to the dam. The equipment, from the U.S. supplier Rotec Industries, consists of about 5 miles of fast, movable, and rotating conveyors.

As the dam progresses to its eventual height of 607 ft, six tower cranes specially fitted with jacking systems will raise the conveyors. In addition to their lifting capacity, the tower

cranes have swinging telescopic conveyors that are designed to pour concrete at the impressive rate of more than 600 cubic yards per hour. A mobile crane delivers concrete from a large hauler to construct the dam's left training wall. Because concrete generates a considerable amount of heat as it sets, large volumes can become exceedingly hot, damaging the material's structural strength. Hence, curing of concrete is essential to keep it at a temperature of about 45 °F (7 °C) as it hardens.

The construction pit for erecting the main dam was dug to a depth of 260 ft, allowing the foundation work to begin. Numerous holes (with a total length of more than 60 miles) are currently being drilled into the ground and filled with pressurized grout. This "grout curtain" will help protect the main dam from uplift by preventing water from seeping underneath the structure. (For the same purpose, 870,000 sq ft of concrete walls were sunk below the transverse cofferdams.)

To facilitate transporting thousands of workers to the construction site, the government built a four-lane highway from Yichang, the nearest city of significant size. By any standard, the \$110-million road, which cuts through the mountains that frame Xiling, was itself a considerable undertaking: 40% of its total length of 17 miles consists of bridges and tunnels, including a twin bore that is more than 2 miles long. Additionally, a 2,950 ft suspension bridge, the longest in Mainland China, outside of Hong Kong, was built at Sandouping for access to the project's right bank.

The double-way, five-step flight ship lock was carved from granite on the river's left bank and lined with concrete. To carve space for the multiple chambers of the lock, workers had to blast with precision more than 75 million cubic yards of hard rock.

The construction progress can be described as follows:

- **Land requisition in dam site:** The total construction area of dam site is 3,700 acres (15.28 km<sup>2</sup>). The land requisition and relocation of 12 thousand residents have been finished and an enclosed management in-site area carried out.
- **Internal and outside transportation:** The expressway from Yichang city to the dam

site and Xiling Bridge across the Yangtze River have been in operation since October 1996. Main docks and an internal road system at the site area have been finished.

- **Aggregate processing and concrete batching plant system:** Two aggregate excavating and processing systems have been constructed and are able to supply coarse- and fine-size aggregates for concrete mixing. With the addition of two other concrete batching plant systems, the concrete production rate could reach 2,380 m<sup>3</sup> per hour, which can satisfy the capability of 550 thousand m<sup>3</sup> per month concrete placing. Each batching plant has its own cooling system that guarantees a 7 °C temperature for cooling concrete in the summer.
- **Diversion works:** Completed; diversion channel opened for navigation on schedule.
- **Temporary ship lock project:** Completed; put into operation on schedule.
- **Ship lift:** Excavation work and concrete placement completed on schedule.
- **Permanent ship lock:** The following were completed on schedule: Surface and underground excavation, excavation work for the lock chambers, concrete placement, underground excavation of the water feed and empty system including inclined shafts and gate shafts, concrete lining.
- **Non-overflow dam sections:** The concrete placement of the left and right bank non-overflow dam sections was started in 1996 and 1997, respectively. Currently, several segments have reached an elevation of 120 m with the left abutment dam sections having reached to the crest elevation of 185 m.
- **Left bank intake dam sections and powerhouse:** Concrete placement of No. 1 to 6 intake dam sections of left bank was started at the end of 1997. No. 1 to 6 units of the left bank powerhouse are planned to be the first batch of generators put into operation. Because of its convenient construction condition, the excavation of the powerhouse for No. 1 to 6 was arranged in the first construction stage and was finished at the end of 1997. The concrete placement was started in January 1998. At the end of 1998, the

No. 1 to 5 powerhouse concrete placement of the basement and the tailrace tube were basically finished. The excavation for No. 7 to 14 units was finished by the end of 1998. Concrete placement is in progress.

### Conclusions

When completed, the TGDP of China will be the largest water conservancy project as well as the largest hydropower station and dam in the world. Technology is being challenged and stretched to the limit as never before to face a variety of engineering challenges in the construction of the TGDP. This includes many aspects such as site preparation, the dam's foundations, the details of the project's main structures, some of which are carved in very hard rocks, not to mention having to work under ever-changing weather. Production rates never before attained are becoming the norm in order to keep the sizable project on schedule. After the completion of the project by 2009, the technology used in the construction of the dam will probably need to be enhanced in light of lessons learned.

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After the completion of the TGDP, precise flood control can be achieved and enormous hydroelectric energy will be produced annually, replacing coal consumption and saving the environment. However, this will not be without cost considering the negative effects such as submerging numerous cities, towns, and villages and inundating some of the best farmland, besides threatening wildlife, not to mention the resettlement of almost 2 million people.

The TGDP is a massive effort in technology transfer. The author asked the chair of the Association of Retired Engineers in Chongqing whether Chinese people are proud of the Great Wall more than they are with the TGDP. After a moment of deep thinking, he stated with a smile that "the Great Wall was built by the Chinese people, and it is indeed their pride, but the Three Gorges Dam is being built by the whole world, so it should be the pride of the whole world!"

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## Scientific & Technological Literacy Through TechnoScience2000+: An Approach for In-service and Preservice Training

Eric Parkinson

### The Challenge of Scientific and Technological Literacy

Scientific and technological literacy (STL) is becoming one of the central planks for development through education on a global scale. Within this global thrust, design and technology in particular are gaining strength as curriculum components either as an individual subject or as contributors to a more broad and inclusive approach to learning (Growney, 2000). A declaration by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 1994) recalls that our world is being increasingly shaped by science and technology, and that these key elements play a role in enabling us to cope with change, pursue development goals, make informed decisions (often with an environmental dimension), and expand investment in human development itself. Educational concerns, therefore, will need to focus on empowered citizens who can lead productive, high-quality lives and who are able to resolve the variety of societal problems stemming from issues such as population, health, nutrition, environment, and sustainable development at local and global levels (Holbrook & Rannikmäe, 1997).

The notion of *literacy* is seen as a mode of behavior rather than as a literal interpretation that concerns the utilization of written and printed information in order to function in society. This mode of behavior is itself complicated but may be one of the key indicators that STL is an appreciation of the *outcomes* of the application of scientific and technological activities. This may also have an environmental dimension, and may embrace notions of environmental literacy (Coppola, 1999). Since the mode of behavior concerns outcomes, and since outcomes affect our surroundings and ourselves, STL also has a moral and ethical dimension with values developed from a diversity of cultural and social settings.

STL, as a principal mechanism driving educational change, is becoming a beacon to which interested parties are drawn for guidance and inspiration. Beyond the rallying call to which groups may unite under the STL banner, Jenkins

(1997) pointed out that like scientific literacy, technological literacy is a slogan, not a prescription for action. This is a useful cautionary note. Clearly there has to be some substance from which to turn well-directed but perhaps vague STL intentions into meaningful actions.

In this respect, some of the core questions driving the desire to increase STL may point towards purposeful prescriptions for action. What is the relevance of much of the content of science? Are scientific ideas accessible? What impact does science and technology have on society? To what extent can technology act as a contextual lead to science education? This link between science and technology is clear if science is perceived as a living discipline that can only be understood through experiencing the interaction of its concepts and processes in everyday life and, hence, through technology. In order to make science "real" and useful, it becomes necessary to reflect on the nature of technology that surrounds us. We are increasingly surrounded by consequences arising from our interactions with the natural environment through the construction of the made world. The great complexity of the made world can be seen as an over-arching summary of achievements (and failures) to apply technological ideas to perceived problems and attempts to elevate the living circumstances of the global population.

If STL is to become an effective component within global education, then the battle cry for change and development by educators will need to undergo a significant act of translation. It will need to be moved from a worthy but general intent to the implementation of active teaching and learning strategies in classrooms the world over. STL will need to become imbedded within the wider curriculum to the extent that teachers from elementary education upwards will understand and embrace its philosophy, formulate new goals, and facilitate effective classroom delivery. Clearly this is a massive challenge.

Significant changes will have to be made in the way preservice education is offered to intending teachers. Perhaps the biggest challenge will concern the vast pool of existing teachers

for whom in-service education will be the principal route by which they can gain access to fresh approaches to teaching and learning.

### In-Service and Preservice Education: The Dilemma of Delivery

Face-to-face modes of education delivery have been at the heart of the school and college-based curriculum for a very long time. The transfer of skills and knowledge by our cave dwelling ancestors was conducted on the basis of close personal contact. The hunting of bears, for example, would have required organizational skills coupled with a past knowledge of the behavior pattern of these animals when faced by a crowd of stone-throwing and stick-waving people. The transfer of skills and knowledge was conducted, perhaps, after a hunt over the glowing embers of a fire during the social act of sharing food. With the coming of the written word, the transfer of skills and knowledge has become decoupled from face-to-face interaction. Books, and increasingly a range of other media such as radio and television, have provided access to learning not only as a component of formal face-to-face channels, but also via a powerful informal pathway.

Even the linear pattern to learning, so well entrenched in activities such as the standard cover-to-cover reading of books and viewing of videotaped material, has been challenged. Modern learning can be nonlinear. Hypermedia resources have determined a fresh chapter in the story of learning. The learner is presented with choices, and the development of appropriate computer-based navigation skills can enhance the direction and pace of learning itself.

In many developed nations, in-service and preservice training of teachers has embraced much of the multimedia enhancement that modern information communications technology can achieve. Formal courses with reading-based components may have these distributed to learners through the Internet. This may be referred to as "distributed learning." The utilization of Internet-distributed texts or locally networked supporting media may be used to complement face-to-face delivery.

Nonetheless, aspects of such delivery generally require the learner to join other participants in a set place at a set time. While great advantages are to be gained from this social learning setting, participation is denied

to those who cannot regularly travel to this fixed point at required times, and as a result such measures may become exclusive.

In developing countries, these factors may act as a brake on widening participation to a significant degree. As an over-arching theme, poverty not only reduces the ability to travel longer distances, but also affects both the reliability and security of such movement. Uncertain journeys induce a negative impact on regular, fixed-point, fixed-time social learning settings.

### Widening Participation in STL

Clearly, the notion of disseminating the STL message will need to be open to a range of options if it is to be effective in the developed world and in developing countries.

Nonformal modes of dissemination in particular will have a part to play, including perhaps a reduction in face-to-face settings for learning. Bardowell (1999) outlined a variety of strategies for popularizing science and technology in the developing country setting of small island states in the Caribbean. As part of the evolution of education, an emerging "degathering" scenario is contrasted with one of traditional "gathering." This emerging "degathered" scenario identified by Bardowell is location independent, is learner directed, is lifelong or continuous, involves decision making and problem solving, and is of an interactive nature.

Degathering may be appropriately served by Internet-based learning measures. The personal computer is increasingly becoming location independent. Wireless communication can extend links to the Internet beyond the reach of telephone lines. Even solar-powered computers challenge our conception of the computer as a device that directly or indirectly gains electric charge from a conventional main source.

Hypermedia presentations can enable learners to direct the ways they wish to learn. Continuous or lifelong learning is well served by the computer. Progress in teaching and learning issues are matched by developments in both software and hardware. Learners embarked on the long haul to self-enrichment will be continually challenged by a tide of change. Even elements of problem solving can be effectively dealt with via Internet access modes that have the potential to provide a rich learning setting with text, moving and fixed graphics, and sound.

### TechnoScience2000+: A Resource That Can Assist “Degathering”

The upgrading of scientific and technological background knowledge and confidence has long been seen as one of the major challenges facing the existing elementary teaching force.

Over 15 years ago, the following comment was made in the context of science in United Kingdom primary schools.

The greatest obstacle to the continued improvement of science in primary schools is that many existing teachers lack a working knowledge of elementary science. Making good this deficiency is a long-term aim which calls for a range of provision within and outside the school. The main elements needed are: (a) Courses and materials which offer or consolidate a foundation of scientific knowledge which will give teachers the confidence necessary to teach science.... (Department of Education and Science/Welsh Office, 1985, p. 8)

The preceding quote must be seen in context. It is not just about science, but about technology also. It should be noted that within the curriculum of the 1980s, science for primary-age children in England and Wales was so closely linked to elements of technology that the two were seen as part of a continuum of experience.

Today, the challenge of providing materials to consolidate a foundation of knowledge in both science and technology is of significance far beyond the shores of the United Kingdom. It reaches into all countries. Development and education are inextricably linked. The key elements that still affect teachers in elementary school situations concern the development of a working subject knowledge and the confidence to deliver this to children. This challenge is being met by a generation of new materials, some with an Internet capability for distributed learning such as TechnoScience2000+.

TechnoScience2000+ has had a long period of historical development. The open/distance learning structure found in TechnoScience2000+ was originally developed in the late 1980s as a text-based set of resources to assist teachers in upgrading their knowledge and understanding of science. Development financial aid was provided by two science-based organizations connected to the pharmaceutical industry, Pfizer

and the Wellcome Foundation. The original texts were extensively tried, tested, and modified in the light of experience. As the curriculum in England and Wales accommodated the “new” subject of primary design and technology, so too did the forerunner of TechnoScience2000+.

Successful collaboration between an educational institution, Canterbury Christ Church University College, and British Nuclear Fuels Limited led to the production of a set of open/distance learning resources entitled “Success with Primary Technology” (Parkinson & Plimmer, 1995). At this stage in the development of open and distance learning materials, it was becoming clear that the Internet could not only have greater potential outreach than hard copy text, but could also be adapted to suit different purposes far more easily than a commitment to paper-based resources. With the switch to an electronic format, another industrial partner, the ICI Group, joined forces with Canterbury Christ Church University College to produce the united set of science and technology resources now known as TechnoScience-2000+. TechnoScience2000+, then, is a set of electronic materials developed to provide flexible learning options for a variety of potential users. The materials are not presented as a formal course, although with adaptation, they could fulfill this function.

The essence of the TechnoScience2000+ materials is that they are a flexible resource in themselves. They are capable of being read online as an informal learning experience, capable of being downloaded as a file for reading as hard copy, and, crucially, capable of being altered, adjusted, and fundamentally rewritten to suit the needs of potential users.

TechnoScience2000+ can thus be utilized as a mechanism for professional development with advisors, teachers, and curriculum developers rewriting materials to suit their particular in-service or preservice delivery circumstances. This notion of localized development of resources is central to what Holbrook (1999) has defined as the “operationalization” of STL. With the use of TechnoScience2000+, such a mechanism enables participants in STL curriculum development initiatives to invent their own “curriculum wheels,” but from a basis of existing, appropriately shaped pieces rather than piles of raw materials.

The TechnoScience2000+ materials are being increasingly linked to initiatives by UNESCO. This situation has arisen due to the joint promotion of human and curriculum STL development by the ICI Group in association with UNESCO. As a global specialist chemical company, the ICI Group has been able to facilitate development workshops at company production and research and development facilities around the world. The provision of sites for development activity has linked exceptionally well to the strategic UNESCO objectives concerning the “training of trainers” (ICASE, SEAMEO-RECSAM & UNESCO-PROAP, 2001) to facilitate STL dissemination.

Two brief case studies concerning STL dissemination are outlined later in this account.

### TechnoScience2000+: The Core Philosophy

As a mechanism for widening participation in STL, TechnoScience2000+ has incorporated the following elements into its foundations.

#### *Science and Technology Content—A Partnership for STL*

In terms of content, TechnoScience2000+ has been developed as a resource in which science and technology are seen as equal partners. No clear subject distinctions have been drawn. This reflects the view taken in some countries that clear distinctions between science and technology as curriculum subjects may be unnecessary. It also reflects a science/technology/society (STS) view that problems, questions, debate, probing, and conflict can be grounded in the science-technology continuum (Yager, 1996) and that STS can become a force to integrate these quintessential and persuasive characteristics of our culture into all the traditional learnings of society (Yager & Roy, 1993).

#### *The Importance of Contexts*

Recognition of the role of contexts is central to the development of TechnoScience2000+. This is achieved at two principal levels. First, industrial workplace-related situational contexts are used as introductory texts. These have a textual narrative delivered by the people directly involved. For example, an industrial safety officer indicates the problems of maintaining a safe working environment, whereas a materials scientist explains new approaches to the use of starch as a biodegradable material for foam packaging. These examples provide a perspective beyond

school settings and help to establish the credibility of the resource itself. It is bonded to real people doing real jobs immersed in the research, commercial, and industrial culture of science and technology. This is a positive outcome arising from collaborative actions between industry and education.

Second, TechnoScience2000+ attempts to utilize everyday technological settings as contexts for exploring scientific ideas. This fluidity of approach is consistent with that of Johnsey (1999) who, as part of an alternative model for curriculum delivery, was concerned with “the integration of science and design and technology so that learning in each subject enhances the other” (p. 15). Venville, Wallace, Rennie, and Malone (1999) had a similar approach to curriculum integration based upon technological problem-solving contexts that direct participants towards abstract scientific concepts through engaging, technologically-based practical tasks.

The technological settings sketched out in the TechnoScience2000+ resource embrace engagement with scenes actively surrounding the learner. A gaze from a window to the scene outside or a “thought experiment” becomes the link to wheeled transport and thus leads to notions of motion and mechanism. Examination of the building materials that may surround the reader can lead to questions of the appropriateness of substances in the made world for certain purposes.

#### *Employment of Innovative Elements in the Resource Text in Order to Engage Users*

TechnoScience2000+, although portrayed as an Internet resource, is based largely upon a flow of text, which can be either considered as an on-screen display or printed hard copy. Text, of course, is a symbolic medium that can convey information to the reader. Success in conveying information to the reader is dependent on reader skills and attitudes related to factors such as comprehension, reading speeds, and attention levels. Motivation to read is a further significant factor. One of the factors that influences motivation is the appeal of the text itself. Research into this domain (Hidi & Baird, 1988; Schank, 1979; Shimoda, 1993) has suggested that text embracing important life themes and vivid details, especially when written in a narrative format, increases the intensity and effectiveness of the reading experience.

TechnoScience2000+ has been written with this in mind. It has a narrative style and attempts, as far as possible, to reach out to the learner with situations communicating “interesting” sets of circumstances (Plimmer, 1996).

#### *Learning in the Workplace*

As part of teacher in-service education, learning in the context of the school has many strengths. TechnoScience2000+ has been developed upon the premise that teaching situations can provide appropriate platforms for enhanced contextualized learning. Barnes (1976) made a distinction between two strands of knowledge. “School knowledge” is seen as knowledge presented by others and tested in formal settings, but it is characterized by being “outside” individuals because it is not seen to be useful for personal purposes. This contrasts with “action knowledge” that becomes incorporated within mental schemata and serves everyday actions. By placing learning through TechnoScience2000+ within the context of the workplace, the acquisition of relevant action knowledge should play a significant role.

The action-knowledge perspective of Eraut (1994), which underpins the development of knowledge in the context of real-life classroom situations, supports such a view. Central to the hypothesis of Eraut is the notion that as well as learning taking place prior to knowledge use, learning also takes place during knowledge use.

TechnoScience2000+ with its wealth of classroom-related situations can form an appropriate base from which action-knowledge can be developed. Subsections of the text are punctuated by “In your classroom” scenarios that encourage the user to reflect and use knowledge gained from the learning materials.

#### *Acknowledgement of the Social and Environmental Context of Technological Applications*

An attempt has been made to highlight links between technological actions and social/environmental consequences. This link embraces the notion of “Bildung” (Hansen, 1994) by augmenting STL with aspects of character development and moral autonomy. Such a reflective attitude should enable users to question aspects of their own lifestyle, uncomfortable as that may often be, so they may engage fully with the Big Ideas that will exert increasing pressure on the environmental agenda for the new millennium.

#### *Where May TechnoScience2000+ Be Used?*

It may be used anywhere. It is a misconception to believe that electronic resources can only bear influence via the modern setting of an Internet terminal. TechnoScience2000+ materials can be downloaded as files and printed out. They can thus be employed as a “traditional” paper-based resource remote from the point of Internet origin.

Resources such as this can be used by local teaching associations as vehicles for curriculum and professional development. This has already occurred in Jamaica, where materials related to the prototype for TechnoScience2000+ were employed at the local teaching level and the national level by the government Core Curriculum Unit to inform the emergence of a new curriculum (Parkinson & Swire-Walton, 1997). At a recent UNESCO-supported workshop in Kingston in September 2001, the latest generation of TechnoScience2000+ CD-ROM materials were provided for Jamaican teachers. This occurred in conjunction with an island-wide initiative to provide all government-funded elementary schools with personal computers. Such an initiative was timely, since teachers now have CD-ROM resources at their fingertips, both as an on-site resource to assist in STL matters and also as a means of motivation to utilize the technology of computer access that so many of us take for granted.

In Nigeria the materials were employed by local subject-based teaching associations as a means of supporting local Project 2000+ initiatives. The Early Learning Science Series for Africa is one such initiative in which science and technology, along with environmental education, plays a leading role (Bajah, 1999). TechnoScience2000+ should become an appropriate in-service tool to assist in the teaching of a core curriculum for primary science, since it is founded upon science-with-technology themes embracing technological capability for the world of work, energy, health, and environment (Federal Ministry of Education, 1991).

For a UNESCO-supported workshop held October 2001 in Argentina, the materials were translated from the original English text into Spanish. Since the addition of a second world language, global penetration by the TechnoScience2000+ materials has been massively increased.

UNESCO development workshops held in the Far East during 2002 will lead to a Chinese version of TechnoScience2000+ in 2003.

#### **A Cautionary Note on Virtual Learning Environments**

As a contribution to global STL, the role of TechnoScience2000+ has to be seen in perspective. Within education via information communication technology, there has been rapid progress towards the creation of learning situations based entirely upon a flow of computer-based information, assessment activities, and simulations or, as these are sometimes called, “virtual learning environments” (VLEs). Such virtual settings are perhaps the ultimate form of degathering.

Hopefully, TechnoScience2000+ will not become some fragment within a totally degathered virtual learning framework to promote technological literacy. TechnoScience2000+ is ultimately about people and for people. VLEs may offer exciting possibilities in terms of the distribution of learning materials and measures for the monitoring of student performance; however, the displacement of all face-to-face social learning may be seen as a retrograde step. The quality of a learning experience depends upon the interaction of a range of variables, including the prior experiences and attitudes learners carry with them and the characteristics of the task environment in which learning will take place. Research by Richardson and Turner (1999) suggested that a significant number of learners increasingly imbedded in VLE settings find themselves isolated and needing the forces of external motivation that only face-to-face situations can supply. It is hoped that TechnoScience2000+ will become part of a new generation of hybrid delivery systems that acknowledge the value of some aspects of face-to-face social learning while taking advantage of the enormous opportunities for dissemination offered by the Internet.

#### **The Electronic Future**

Opportunities for electronic dissemination

are increasing all the time. The merging worlds of computers and telecommunications have a habit of leapfrogging perceived barriers to the widening of participation in the information communication technology arena. At one time, disadvantaged communities cited the lack of hard-wired infrastructure as a barrier to progress. Wireless communications are rapidly re-writing the telecommunications infrastructure chapter in a way that could not have been imagined 10 years ago.

Broadband communications are set to have a similar effect in terms of the density of information transfer that can be accommodated on the Internet. Perhaps, in time, the blisteringly hot data transfer rates we have seen on hard-wired systems will become part of the wireless scene also.

Through the scale of recognition now offered by UNESCO, TechnoScience2000+ will be part of this ongoing educational electronic revolution. Interestingly, one way of judging the “success” of the ability of the resource to interact with educational training systems will be to see how it is progressively taken and reconstructed by users. In, say, 10 years time TechnoScience2000+ may well become a diverse resource that has used elements of the original core text, yet modified this as local communities of curriculum and resource developers make adaptations to suit local needs.

The translation of the resource into Spanish in Argentina is the most dramatic indicator of this drift toward local adaptation and change. This, of course, is not simply a change of language, but within it are hidden all the subtle subcontexts and meanings bound up with language and culture. In many ways, this is a symbolic act.

The operationalization of STL both through and for an electronic age is truly underway.

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## Achieving Education for Technological Capability in Scotland

Susan V. McLaren

### A Framework

*Technology Education in Scottish Schools: A Statement of Position*, an initiative of the Scottish Consultative on the Curriculum (Scottish CCC, 1996), provides the rationale for all curriculum development in technology education in Scotland. It has influenced the Higher Still<sup>1</sup> qualifications entitled Craft and Design, Technological Studies, Graphic Communication, Home Economics, and Art and Design for the Scottish Qualification Authority (1999). The National Guidelines for 5-14<sup>2</sup> Environmental Studies, Technology (2000) has technological capability (see Table1) as its attainment outcome.

Design and technology (D&T) education involves learners coping creatively with complexity. It must take account of a wide range of often apparently conflicting demands and constraints: aesthetic, economic, political, ethical, social, and environmental as well as ergonomic, technical, and scientific. The framework for technology education, described by the Scottish CCC (1996), promotes narrow *proficiency* tasks that provide opportunities to acquire the specific skills, strategies, and knowledge that are required to engage effectively in design and technological activities. These underpinning proficiencies can be developed through direct teaching via closed or focused briefs. This allows specialist inputs and knowledge to develop concurrently with more generic technological

concepts and facilitates teaching and learning for transfer. *Creative practical tasks* offer opportunities for open-ended design and realization through practical action in response to perceived needs, wants, and opportunities. *Case study tasks* describe a relatively recent approach to school-based D&T learning. These involve students in the study of technological applications in the wider world and its interactions with society and the environment. A case study can provide the stimulus or context setting for the creative practical task. It can serve as the vehicle for comparing and contrasting different solutions, cultures, or times, or more detailed aspects of design and engineering. Case studies can involve fieldwork and/or incorporate inputs from adults other than teachers and from related areas. They have the potential to raise issues and offer stimuli for alternative resolutions. It is through interactive case studies that teachers are able to make connections between the technology their students are studying in school and the wider society, industrial, and business context. Case studies encourage students to evaluate and make informed judgments about the appropriateness of the technological products created by others and to speculate about possible future developments. Students can begin to consider, critically, the impact and influence of D&T on society and the environment. Students can start to appreciate the consequences of the interaction of D&T with society and the environment.

**Table 1. Technology Education in Scottish Schools: Summary of the Aspects of Technological Capability (Scottish CCC, 1996)**

<i>Technological sensitivity:</i>	Appreciate that technological developments have consequences for people and the world in general, apply moral and ethical judgments in evaluating technologies and considering effects that proposed solutions have on the well-being of individuals, societies and the local and global environment; etc.
<i>Technological perspective:</i>	Develop a way of seeing and thinking about the world past, present, future; think imaginatively about better ways of doing things; appreciate the factors contributing to the success of a well designed product; appreciate the relationships between technology and the world of work; bring an inquisitive mind to bear upon the made world; etc.
<i>Technological confidence:</i>	See technological opportunities, identify technological problems and take on challenges presented by these; question ideas, design and products; etc.
<i>Technological creativity:</i>	Make effective use of knowledge, skills and experience; develop imaginative and feasible approaches and resolutions; manage appropriate materials, equipment and human resources; critically evaluate, amend and adapt strategies; design and/or make technological products or modify existing; etc.

### Case Studies of Design & Technology in Action

As well as being of interest in their own right, the products explored in the CD-ROM *Exploring Everyday Products: Case Studies of Design & Technology in Action* provide examples of how to use a case study approach. The case studies help to explain how to evaluate products in relation to technology in society. They exemplify how to explore the issues and lead into activities to stimulate detailed appraisal and understanding of product, industrial cycle, respective roles of clients, users, consumers, designers, engineers, production team, sales, and marketing.

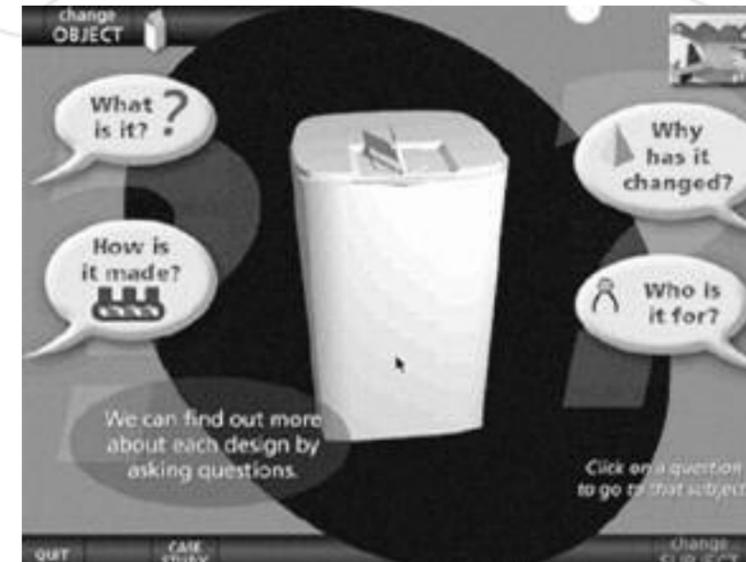
To ensure that the CD-ROM does not end up as a passive story time, two-dimensional activity, the case studies require pupils to have a hands-on experience of examples of the products under scrutiny, or similar. Therefore, the products were chosen for their accessibility and familiarity. It was also considered important that the products chosen could be explored in stages

appropriate to students in the 8 to 16 age group and offered opportunities for individual and group work. A variety of product types was needed so that the chosen products illustrated the technological design issues that are central to this learning resource, such as scientific/ technological principle of function; choice of materials; manufacturing processes; obsolescence; environmental and social conditions; evolution marked by historical, technological, and social factors; user analysis/consumer demand; ergonomic values; marketing strategies including advertising; fashion; and variation in scale. This involved detailed collaboration with local and national industries for the case study information.

The process of selection of products resulted in the following:

- Packaging for milk—Robert Wiseman Dairies PLC.
- Telephone—Motorola PCS.
- Tents—Vango (Scotland) Ltd.
- Radio—Freeplay Energy.

**Figure 1. Example of CD-ROM screen graphics and content.**



- Weighing machines—John White & Son (Weighing Machines) Ltd and John White Automation Ltd.
- Tin-opener—Ken Grange Design.

### Development and Design of the CD-ROM Resource

The multimedia potential offered by CD-ROM allows access to the information, ideas, and artifacts that would otherwise not necessarily be possible in the classroom. It is intended that the product case studies selected will captivate the imagination of both teachers and students alike. It is anticipated that users will develop a sense of curiosity and be encouraged to delve deeper into the values, attitudes, and influences that lead to the development of such products, innovations, and enterprises. The case studies featured on *Exploring Everyday Products* aim to help pupils to:

- reflect critically and constructively on the interplay between technology, society, and the environment, now and in the past, locally, globally, and in various cultural settings;
- develop technological capability, particularly focusing on technological sensitivity and perspective;
- explore the interactions of design and technology with society and the environment;
- understand that design and technology activity has a persuasive influence;

- question the appropriateness of products;
- begin to understand the complexity of factors that influence any product, including the role of the media; and
- ask questions about, and consider future possibilities of, the impact of technology on national economies and quality of life.

### Exploring the Everyday Products

Pupils are introduced to *examining* and *reading* a product through:

- initial emotional response, both their own opinions and judgments and those of others as exemplified by comments from focus groups;
- illustrated historical development of the product;
- detailed product autopsy and disassembly, including identification of materials, manufacturing processes, and assembly procedures;
- analysis of function and its relationship with materials and processes;
- end-user tests and reports;
- environmental audit or critique;
- impact of product on lifestyle, society, the economy, and company portfolio, including discussion of issues and values of the product and its purpose; and
- interactive tasks that involve the pupils in making choices or basic design decisions.

**Table 2. Classroom Trial Activities: Focus and Tasks**

Activity	Focus	Task
1. Tents	<ul style="list-style-type: none"> <li>• Introduction to structures</li> <li>• Pre-planning</li> <li>• Scale (1:10)</li> <li>• Sketch modelling</li> <li>• Group work</li> </ul>	Design a structure for 3 campers with belongings and boots
2. Radio	<ul style="list-style-type: none"> <li>• Awareness of energy sources used in common domestic appliances and machines</li> <li>• Finite versus renewable sources</li> <li>• Sketch design ideas</li> <li>• Annotation</li> <li>• Product evolution over time: style, technology and size</li> </ul>	Design an everyday appliance or machine which is powered by a renewable energy source
3. Milk	Packaging same job, different product driver for changes over time manufacturing process color and image association market target group role of focus group evaluation	Design a milk package for specific target

The design decisions for navigation pathways for the CD-ROM user to follow were based on having a common entry point for each different product. This leads the user from the main menu (a campsite) into the product introduction screens before a choice of routes is made available for either a directed path or the possibility of linking themes across the six products, for example, What is it and what does it do? Who is it for? Why has it changed? How is it made? (see Figure 1).

#### Teaching and Learning Stimuli

Included in the teacher's notes are suggestions for integrated activities, both on- and off-screen learning approaches that vary in scope and duration. These range from ideas for design tasks, knowledge, and understanding focused tasks and skill development tasks to research-informed discussion and report-writing tasks. This guidance aims to encourage teachers to devise programs of work that are informed by the content of the CD-ROM or progress into a complementary open-ended creative practical task as a result of studying a specific case study.

McLaren (1997) stressed the importance of giving students the opportunity to reflect on their explorations of a value-based appraisal of

technology in society and allow their reflections to influence their own approach to design. She cautioned against reducing the technology curricula to learned sequences of procedures and mechanical application of acquired skills and knowledge and understanding. Design opportunities do not present themselves in neat packages. The CD-ROM case studies/stories illustrate this. The perceived needs and wants from which the resulting products arise must be determined from ambiguous, unstructured scenarios and formulated in such a way as to allow the so – called problem to be solved. The various perspectives, influential factors and constraints, and value judgments of those involved bring a diversity of opinion and interpretation to this front-end process. Often in school-based technology activity, the students are encouraged to follow a design process as an algorithm (McCormick, Murphy, & Davidson, 1994). This over – simplified, ritualistic approach does little to help students appreciate the complexity of decision making involved in design. Many conceptual insights and values are hidden within the end product, and access to the design thinking is not necessarily evident. Creative use of the opportunities offered by information and communication technology media of the CD-

ROM and the WWW may help students to dig deeper and begin to appreciate the wider connections and influences the designer has to deal with in the rationalization of the complexity.

#### Early Stage Evaluations

Central to the development of the CD-ROM was the usability in the classroom by both D&T specialists and primary teachers. The teaching and learning resource was to address areas of concern in current teaching practice and to provide the teachers with a tool to explore environmental, cultural, ethical, economic, societal, technical, and historical issues with their students. It was important not only to ensure that the content and coverage was appropriate but that teachers were involved in the development process. An advisory group of practicing teachers was, therefore, consulted throughout the process. Following the completion of three product stories, class trials were conducted in the schools of the advisory group members. These early evaluations informed the work and enabled certain issues to be identified, particularly about navigation through and between the various product types. It was also apparent that secondary teachers identified more readily with the CD-ROM's content and style than their primary colleagues. Requests were made for detailed guidance on how it could be used in school, with a glossary for design and technology terms and technical vocabulary. At this stage it was encouraging that the teachers were complimentary about the cultural aspects and the industrial and business connections. Many of the issues, concerns, and ideas from this group were addressed and adopted, where budget permitted, and work continued on the development of the remaining three product stories.

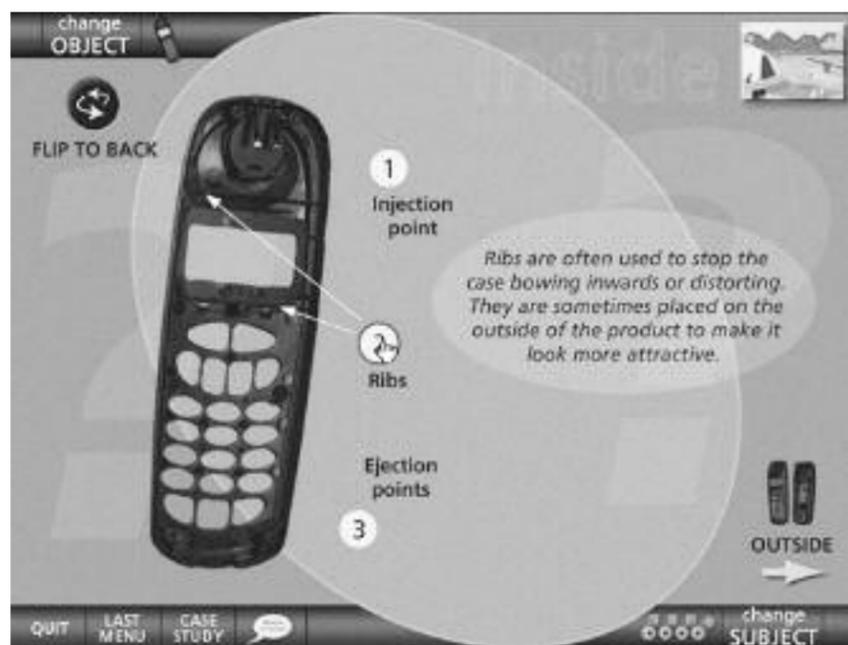
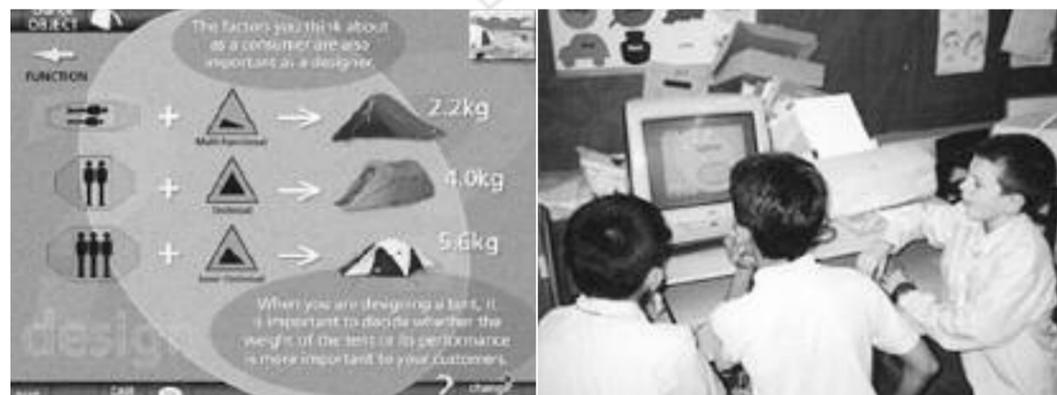
#### School-Based Trials and Evaluation Responses

In order to gauge the response of pupils and teachers to the content, format, and potential of *Exploring Everyday Products*, school-based trials were conducted in addition to opinions being canvassed from practicing secondary and primary teachers. Since the design of the CD-ROM was based on the concept of mutually supportive and interrelated tasks, both on- and off-screen, each classroom trial consisted of a mixture of CD-ROM viewing/reading and a physical activity such as designing or an integrated design-make task (see Table 2). At the end of the session the pupils completed an evaluation

form. The product stories/case studies for class-based trials and evaluation were selected to test ideas for tasks that aimed to develop specific concepts or skills. The format, content, level at which to pitch the tasks, time to allow, and teaching approaches also required appraisal.

**Task 1. Tents:** This trial was conducted with a class of secondary 3 pupils (14 to 15-year-olds) and repeated with a class of primary 6 pupils (10 to 11-year-olds). Due to the restricted time of the secondary school system, only 53 minutes were allocated compared with the two hours available in the primary school. In brief, the session was comprised of three main components: (a) warm up task, to make a doweling rod stand upright, using only resources found in a box provided for each group; (b) debriefing by the teacher, to consolidate basic concepts of how structures stand up in terms of equal forces, tension, and compression only; and (c) class viewing of the Tents product story on the CD-ROM, navigation by the organizers: *Why has it changed? What is it? How is it made? Who is it for?* Then a design task was tackled in groups: to design and make a model of a tent-type structure that can accommodate three adults, three rucksacks, and three pairs of hiking boots. A 1:10 scale paper template was provided for pupils to cut out and use in their planning. The pupils were permitted to select resources, tools, and materials from the common pool. It was discernible that the source of the primary 6 children's ideas came from the images and information gleaned from the presentation of the CD-ROM.

The children made comments that they enjoyed the making element of the session. One child particularly enjoyed "deciding what to do." This suggests that the initial concept of designing a CD-ROM that would act as a catalyst for away-from-screen activities was based on a reasonable premise. Another pupil enjoyed "finding out about the tents in the olden days." This aspect of the session took a total of five minutes and yet had clearly been memorable. There were varied opinions on what had been learned, including "how to make a tent and how to support a structure," "how tents were made and used," "how hard it would be to make a tent in so little time," "that you must make sure the tent is the right size," "allot," and "not to put you fingers ner [sic] the ponnt [sic] of the glue gun."

**Figure 2. Technical manufacturing Considerations Impacting on Design.**

In response to the question, What did you enjoy the least, there were comments such as “arguing [*sic*] about who does what,” “measuring,” “being quick,” and “being burned by the glue gun.” However, two pupils had liked the CD-ROM the least.

**Task 2. Radio:** This trial started with a discussion about the types of devices, appliances, and machines the children had used from getting up to arriving into school. A wide range of products including alarm clocks, toothbrushes, irons, refrigerators, toasters, bikes, and cars were mentioned. For each product, the children were asked to note the source of the energy that

powered the machine/appliance. This was followed by working demonstration circuits of simple energy conversion using visual aids such as a hydro-powered turbine, a hand dynamo, a solar – powered (photovoltaic) circuit, a fan (wind), a lemon/zinc/copper battery, a steam engine, and batteries.

The group was then introduced to the CD-ROM to view the radio product story/case study. They explored the design and evolution of the radio and had a valuable discussion with each other, stimulated by the on-screen questions and those posed by each other. Some of the comments illustrated a fair level of awareness. For

example, on reading the comment regarding the 1950s styling that was targeted at girls and women and hearing the supplementary information about creating new markets for products, one child exclaimed, “That means that shopping was invented for women!” Others noted that the 1940s style “looks like a juke box.” The 1940 bakelite radio attracted the observation, “Why, when it’s plastic, have they made it look like mahogany?” One member of the group, on seeing the 1980s model, announced, “They managed to make it smaller, because they made all the bits inside smaller. That’s technology.”

*The How does it work? and How is it made?* sections were viewed with obvious interest. Some of the screen frames were visited and revisited by the pupils, with a particular favorite being, “You speak in here...and it comes out here.” “Why, if we know they’re [radio waves] up in the sky, can I not see them from the window of the aeroplane?” and “Is that why the noise is all fuzzy if you move the dial just a wee bit away?” seemed to be evidence of thinking further into the concepts and information being presented to them, stimulating curiosity.

The pupils were then asked to think back to the initial discussion about the various machines and devices encountered in their everyday business. They were to consider how the devices could do the same job using a more sustainable or renewable source of energy than at present. This was a short future-thinking type task, requiring annotated sketches and a debriefing plenary discussion. The specific focus for this trial was to develop approaches to support technological perspective, for example, “demonstrate an understanding of how the made world that they experience has come to be as it is, and indicate ways in which it might be different” (Scottish CCC, 1996, p. 8).

The variety of comments noted on the evaluation forms indicated that there was something to interest and motivate every member of the class and all learning types (Honey & Mumford, 1992). Some preferred the CD-ROM focused work (“doing the radio on the computer,” “looking back in time,” and “learning about old and new and different”), and others enjoyed the design task more. The intended learning outcomes, related to technological perspective and sensitivity in particular, from the pupils’ perceptions seemed to have been met. For example, I learned “there were so many different radios,”

“how useful heat and water is as a power source,” “how radios work,” “how a lot of sources of energy worked,” “some things don’t need a battery,” and “how wasteful batteries are and what else you could use.”

**Task 3. Milk Packaging:** This trial involved secondary 2 pupils (13 to 14-year-olds). Results indicated that this task requires a longer time devoted to it (55 mins) in order to introduce, develop, and consolidate the learning outcomes. By way of context, pupils were shown a range of milk packaging types from various supermarket own brands and other producers. After discussing the style of graphics, use of colors, materials, and types of container, the packages were classified using different headings. Although one carton had been deconstructed, pupils presumed that the cartons were made from cardboard and this was used as the cue to visit the CD-ROM case study and explore the key questions posed therein. The third aspect of this session was the task of designing a milk package suitable for young children. The pupils were to consider the use of color, graphics, openings, and manufacturing processes in the same way as they had been introduced to the information by the CD-ROM. In the resultant sketches there was evidence that a number of pupils used the concepts and issues raised on the CD-ROM in their own ideas. The animation of the carton manufacturing processes (with the cross-reference to injection molding processes from the telephone case study) was a definite hit. This is supported by several pupils commenting that they learned “how much effort it takes to make everything possible” and “how milk packs are made.” Teachers themselves have rarely been in a manufacturing environment and require materials to convey how things are carried out in the “real world.” Introductory teaching materials that illustrate a number of complex industrial manufacturing processes need to be informative, accessible, and realistic without burying the basic information with too much technical detail (see Figure 2). The difference, and sometimes the similarities, between school workshop and industrial practice is central to the journey of the CD-ROM.

### Conclusion

On the whole, these trial sessions were met with great enthusiasm throughout and have provided justification for the final stages of development, prior to distribution to schools.

Appraisals of navigation and presentation issues were favorable. Teachers and pupils found it easy to move between themes. One pupil commented, "It told you where to go, really easy and simple. This is a good thing as it puts you off if something is really complex." The reaction to the animated "campsite" front-page frame was "try to phone," "try the bird," "try the tent," "try the swing," "try the radio. Hey! Cool!" Although initially highlighted as an area of concern by secondary and primary teachers, the written pupil responses complimented the campsite frame. Words such as *exciting*, *interesting*, *cool* and *good* were noted. Also, "I wanted to see how it worked" implies that it served its purpose of enticing the user further into the CD-ROM.

From the information collected from the early evaluations, the field trials, and canvassed opinions, the content of *Exploring Everyday Products* is deemed accessible and of value in the classroom. Evidence from the sample, albeit small, suggests that the CD-ROM does stimulate curiosity about how things are and how they used to be, and encourages speculation about how things might be different. Teachers will have access to informative case studies that specifically enable discussion and design thinking about cultural, societal, and environmental issues, which hitherto have been given little attention. The pupils and teachers seem to have connected with the approaches of the industrial

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## Notes

<sup>1</sup> "Higher Still: Opportunities for All" is the Scottish Qualification Authority framework for school and colleges. It aims to provide a more inclusive and progressive transition between stages of education leading towards qualifications in academic and vocational modules, courses, and group awards at secondary schools and further education colleges.

<sup>2</sup> 5-14 National Guidelines create a coherent framework for the content and structure of the curriculum for primary schools and the first two years of secondary schools in Scotland. In general this

"real" world of design and make and were able to relate them directly into the classroom experience as the activities were designed to do. However, it is agreed by all that the CD-ROM on its own is not enough. Teacher input is required and, therefore, the teacher notes and guidance are a central part of this educational resource.

The products selected have provided a vehicle for on-screen exploration of various technical and commercial considerations while stimulating off-screen tasks through which the pupils can apply their own knowledge and understanding, make their own value judgments, and engage in activities that develop all four aspects of technological capability: perspective, confidence, sensitivity, and creativity.

Overall, the selected CD-ROM case studies and associated tasks underpin an active learning approach to developing technological capability and meet the expectations of the Scottish CCC Technology Education Development Program. The involvement of industry and designers who were directly engaged in the development and marketing of the products was therefore an essential part of the project.

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covers the education of students ages between 5 and 14 years old. Although not statutory, the guidelines suggest the dispositions, core skills, capabilities, knowledge, and understanding to be developed. In addition, the guidelines set out the attainment targets for language, mathematics, religious, and moral education, information, communication, technology, and health education. Our subjects are grouped. These groupings are known as Expressive Arts (art and design, physical education, drama) and Environmental Studies (society, science, and technology).



## Developing Fiscal Measurements to Quantify the Effectiveness of Aging Technology Laboratory Equipment

Jon McDermott

Replacing aging technology education laboratory equipment is often a contentious issue between technology educators and administrators. A possible major reason for this is the high cost of technology laboratory equipment when compared with laboratory-based programs in other disciplines. Administrative reluctance is also reinforced as technology educators accept “hand me downs” from industrial partners to upgrade technology laboratory assets. Too often laboratory educators accept and use “left over” technology laboratory equipment that fails to represent the quality and “leading edge” technology that students deserve. And then maintaining aging laboratory equipment is an expense that administrators resist as they seek to lower capital expenditures. Not only is the cost of maintaining aging laboratory equipment significant, but there is a cost to students of “lost” class time while awaiting equipment repair. Burdened with these challenges, as well as an inability to depreciate technology equipment as commercial users do, publicly funded technology educators who have struggled to justify the purchase of new technology laboratory equipment may benefit from a system of quantifiable measurement strategies that captures the fiscal benefits of new laboratory equipment and the expenses associated

with maintaining aging equipment.

I identify several of the hidden costs associated with operating aging, often dysfunctional, equipment in a laboratory-based technology education program. In particular, my examination involves the laboratory equipment in the Aviation Studies Program in the College of Technology at Bowling Green State University (BGSU). Quantifying the effectiveness, or lack thereof, of our student production has been successful in convincing administrators that replacing aging laboratory equipment is in the best fiscal interest of this laboratory-based education program.

### Link Measurable Revenue Increases to Production

The aviation laboratory equipment at BGSU was purchased in the 1980s and is still used to train and educate aspiring aviation students. This equipment, meeting minimal industrial standards, fails to represent the improvements in technology that have taken place in aviation equipment over the past 20 years. Initial attempts to replace this aging equipment, based on the notion that new equipment would improve student “quality” for their postgraduate career, failed to gain administrative support. A more business-like approach that measured and quantified the benefits to

production, and subsequent accountability of our laboratory education program, was needed. In 1999, I began an effort to measure the impact the age of our laboratory equipment was having on our ability to produce graduates by providing fiscal evidence for university administrators to use in judging the effectiveness of our laboratory-based education program.

Figure 1 represents an analysis of the utilization of BGSU laboratory equipment (aircraft) during the fall of 1999 (McDermott, 2000). Note that this laboratory equipment required maintenance, or had to be “repaired” approximately 12% of the time during that semester. In quantifiable terms, if I needed 2,200 laboratory lessons per semester to meet student production needs, losing 12% to maintenance adds an additional 264 laboratory activities to a 15-week semester, tasking resources beyond limits. Alternatively speaking, decreasing the need to repair laboratory equipment by one half, or reducing this rate to 6%, adds only 132 laboratory activities per semester. This addition, found to be within the scope of current resources, would have produced more graduates and subsequently generated approximately \$13,200 in additional revenue for this particular semester (BGSU, 2000).

Figure 1. Utilization of aircraft resource (Fall 1999)

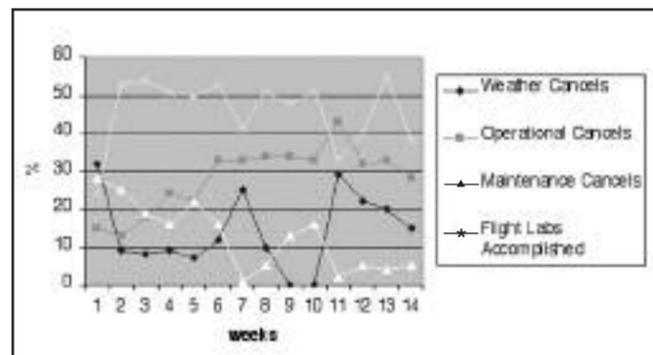


Figure 2. Maintenance costs for A Y00-01.

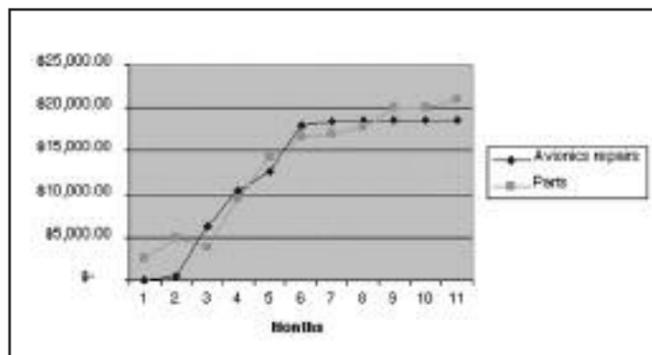


Table 1. Maintenance Activity for Aircraft N5251

Technology Improvement – N345DC	Date	Estimated Cost (then)
Initial aircraft purchase	1980	\$80,000
1 <sup>st</sup> Communications and navigation upgrade — basic radios	1982	\$7,500
2 <sup>nd</sup> Communications and navigation upgrade — improved radios	1986	\$2,500
3 <sup>rd</sup> Communications and navigation upgrade — HIS, basic GPS, DME	1998	\$10,000
4 <sup>th</sup> Communications and navigation upgrade — state-of-the-art GPS, NDB	2000	\$12,500

The ability to provide administrators with measures of the rate at which aging laboratory equipment was breaking, and thereby failing to produce projected revenue levels, was rewarded in July 2000 with the purchase of two new laboratory aircraft. In retrospect, continuing to measure maintenance reduction provided an additional argument for the continued purchase of new lab equipment. Not only does reducing the amount of time an aircraft is lost to production lead to quantifiable increases in program revenues, the costs of repairing aging laboratory equipment is another measurement that can assist educators in quantifying their production effectiveness. Figure 2 presents the rate at which our program expended resources on aircraft repairs (BGSU, 2000). Note that the rate, or slope, of fiscal resources expended for aircraft repairs decreased from January to June, the time period when we began to utilize our new equipment in student laboratory lessons, saving our program an additional \$12,000. Add this decrease in maintenance expenses to the 6% increase in production effectiveness (by having our laboratory equipment break less often), we decreased our operating costs by approximately \$25,000 in that academic year.

The purchase of new laboratory equipment had another measurable benefit for our technology education program that was underestimated in initial estimates, and one that may be applicable to other technology disciplines as they pur-

sue new laboratory equipment. Our new laboratory aircraft arrived with a two-year warranty that added an unanticipated economic benefit to our laboratory program—the costs of repair parts and labor is refunded by the manufacturer! This reduction in maintenance expenses netted an additional \$2,000 in labor savings and more than \$5,000 in savings in the costs of repair parts (BGSU, 2000).

### Keeping Aging Laboratory Equipment Current

The challenge of keeping aging laboratory equipment current in an ever-changing technological environment offers another opportunity for educators to quantify the effectiveness of aging laboratory equipment. In this connection, there is discussion whether a particular piece of laboratory equipment is worth “upgrading,” or can be upgraded. In the case of BGSU’s aviation laboratory equipment, Table 1 outlines the costs of technology upgrades that were required to keep this particular “aging” laboratory equipment current in the navigation and communications technologies our students will use in their future professions.

Although the costs of these upgrades relative to inflation have changed, the argument can be made to administrators that the continual requirement to improve the technology of aging laboratory equipment represents a significant burden on limited resources, impacting adversely on year-end fiscal projections (BGSU, 2000). Perhaps a

better fiscal strategy would be to avoid the cost of upgrading aging technology altogether by developing a plan to purchase new technology from capital resources.

### The Cost of Idle Equipment

Another measurement to consider in examining the costs of maintaining aging laboratory equipment is the impact to laboratory production when aging equipment fails, causing classes to be postponed or experiments to falter. Table 2 presents a review of the time periods a typical aviation laboratory asset was idle awaiting repair during the 2000 school year. Note that in this particular instance, this aircraft was unavailable for use 41 days of that academic year.

To represent the true cost of operating aging laboratory equipment, one must account for the impact that idle laboratory equipment has on production, and subsequent fiscal accountability. In this example, aircraft are typically scheduled for five laboratory periods per day, at \$100 per lab. Forty-one days idle could cost \$20,500 if utilization were 100%. However, Figure 1 indicates a utilization rate for this particular laboratory educational activity of approximately 50% over the semester; the impact on revenue for those periods of time when laboratory equipment was unavailable for teaching equates to an approximate loss of \$10,250. This is a significant impact on year-end fiscal projections, a burden that can never be entirely avoided in any

**Table 2. Maintenance Activity for Aircraft N5251**

Date	Maintenance Activity – N52514	Days Idle
September 99	Order and replace intercom	9
November 99	Order and install new transponder	3
December 99	Order and repair marker beacon lights	4
January 00	Order and replace navigation radio	4
July 00	Fix interior lighting	3
August 00	Order parts and repair navigation instrument	10
September 00	Exchange glide slope receiver and display	4
September 00	Repair wiring harness for navigation instruments	4

equipment-intensive laboratory program.

**Validation—A Case Study**

To add further validity to my argument concerning the effectiveness of the timely replacement of aging laboratory equipment, I needed to examine other laboratory-based aviation education programs with similar operations to that of the program at BGSU. After considering several alternatives, I gained access to the laboratory-based aviation education program at Indiana State University (ISU). In July 2001, I examined the maintenance records of the Brown Flying School in Terre Haute, Indiana, one of two commercial contractors for the aviation education program in the School of Technology at ISU. Brown Flying Service laboratory

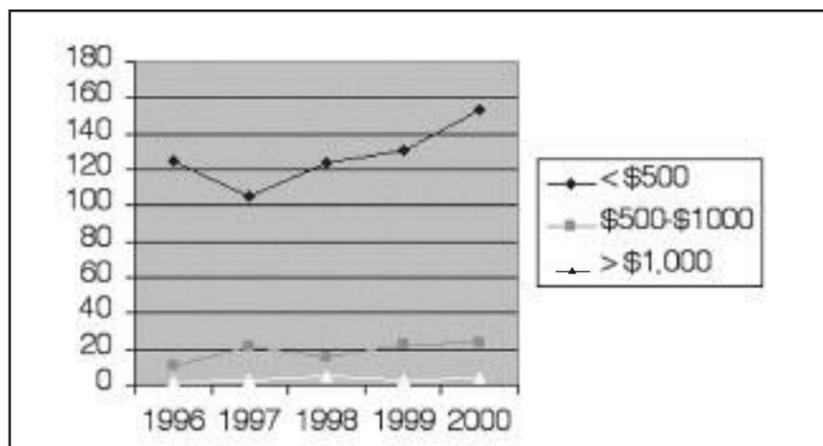
equipment is of the same type and age as that used at BGSU. Brown also maintains its own laboratory equipment (aircraft fleet), as does BGSU, providing similar maintenance database formats. I collected the maintenance data displayed in Figure 3, representing the expenses associated with Brown’s requirements to maintain its aging fleet of laboratory equipment and compared it to BGSU data (McDermott, 2001). I contend that this comparison validates my conclusion that the use of laboratory equipment beyond its reliable life span is detrimental to the effectiveness and fiscal accountability of laboratory-based educational programs. First, the loss of production due to broken lab equipment limits a program’s ability to be as fiscally accountable as other less-

equipment-intensive educational programs. Second, the cost of, and frequency of, equipment repair is incremental and represents a cumulative burden to operating budgets. Third, the cost of upgrading aging lab equipment is an unavoidable expense to operating budgets if we are to offer our students “state-of-the-art” laboratory equipment.

**Summary**

This article offers technology educators an opportunity to review several measurement devices that I have had success with in quantifying the effectiveness of timely replacement of our laboratory-based technology education program equipment. I have been able to use such measurements to convince administrators that in my par-

**Figure 3. Maintenance activity for representative aircraft at Sky King Aviation.**



ticular technology education field, the quality, age, and maintainability of the laboratory equipment is critical to the overall effectiveness and fiscal accountability of the technical educational process. Although I measured the effectiveness of training aircraft in a university aviation education program, I believe colleagues in other technology fields can make similar arguments that will convince administrators that student needs are not met by relying on hand-me-down laboratory equipment. Although any discussion with

administrators regarding replacement of aging technology laboratory equipment tends to focus on the initial cost of the new equipment, I believe my measurement devices can assist colleagues in identifying several hidden costs associated with maintaining and operating aging laboratory equipment.

These fiscal measurements and strategies have been successful at BGSU. However, this may be received elsewhere. I contend that it is worthwhile for

educators to quantify educational efforts in terms administrators understand and in relation to the effectiveness of the laboratory educational process at producing quality graduates and the accountability of that process for public funds.

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**Team-Based Design for Design and Technology Teachers**

Howard G. Denton

Schools and universities are under pressure to develop team working capability in pupils and students. This pressure comes from (a) industry and commerce, as there are strong indications that well-designed team working improves performance (Hoerr, 1989; Saba, 1989) and working relationships (Buchanan, 1989); and (b) education, as there is evidence that cooperative work can support learning generally (Cowie & Rudduck, 1988).

This article reviews some of the relevant literature. The development of team-based design capability is illustrated over the four

years of teacher training in Design and Technology at Loughborough University in the United Kingdom. Finally, issues in developing team-based design capability in schools are identified. In this article a *team* is defined as a number of individuals cooperating in the production of a single outcome; a *group* as individuals cooperating, but producing individual outcomes.

**Background**

Companies are increasingly using multidisciplinary team working. This has been shown to produce a better range of ideas and reduce development time and costs. Buchanan (1989) showed that, with

some exceptions, attitudes improve and self-confidence grows. Recognition of the potential value of team working in industry has meant pressure on universities and schools to give students team-based work experience. There are also broad educational reasons:

**Motivation:** Team working can generate increased levels of student motivation, particularly when the project chosen has direct links to industry (Denton, 1992, 1997a).

**Performance:** Team performance can be higher than the sum of individual efforts

(Peacock, 1989). Gokhale (1995) considered how collaborative learning develops critical thinking through discussion, clarification of ideas, and the evaluation of other's ideas. Team working brings several minds to bear on a problem. These can cancel errors, an "assembly bonus effect" (Driskell, Hogan, & Salas, 1987). However, this cannot explain the improved flow and breadth of ideas in more "creative" team tasks. Hackman (1983) used the term *synergy*, defined as phenomena emerging from interaction and affecting performance; it may be positive or negative. When a team first forms, time has to be spent on developing relationships and identifying the common aim. This can lead to conflict so that less energy is spent on the task itself. In industry, a team may tackle tasks over extended periods and so is able to develop into a cohesive and productive unit. In education pupil teams are usually short lived because the majority of work (in UK schools) is done individually. Tuckman (1965) wrote that teams go through stages of forming, storming, norming, and performing. Only in the last stage is productive work done. The earlier stages are, however, important in establishing team identity and preparing for further work. Austin, Steele, MacMillan, Kirby, and Spence (2001) estimated that with newly formed teams of engineering designers in an experimental setting 21% of project time was spent on social interaction and team maintainance.

**Idea generation:** Team working can improve the range of ideas generated in any context as indicated above. In addition, the process means that individual students see the perspectives of others, helping them to examine their own values.

**Dealing with ambiguity:** Design usually deals with levels of ambiguity and unpredictability. It can be argued that teams are better equipped for dealing with this because of the range of perspectives available. Garner (2001) and Minneman and Leifer (1993) saw ambiguity as a positive aspect of the designer's work in the early stages.

**Multidisciplinary tasks:** Team

working enables individuals with a range of knowledge and skills to work together and solve problems that an individual specialist could not.

**Realistic scale projects:** More substantial tasks may be set. These can simulate whole product design more effectively and give the student a better idea of product development in industry. The scale of such projects can also inspire and motivate.

### Team-Based Design at Loughborough University

The program in Industrial Design and Technology with Education is a three-year industrial design degree with a minor element studying design and technology in schools. This leads into a one-year postgraduate teacher-training course. Experience of team-based work is seen as important for students both as potential designers and teachers. For example, an important part of the department philosophy in teacher training is that teachers should learn to collaborate in both planning and teaching (Denton, 1998; Denton & Zanker, 2000). This can lead to:

- improved cohesion of approach to the subject within a school department,
- teachers learning from each other in terms of both pedagogy and subject knowledge, and
- more efficient in use of staff time and resources.

Within the program there is a spine of formalized team-based design and planning exercises. These progressively extend student experience. In addition, when working on individual work, students are encouraged to form informal groups to extend each other.

#### Year One

Day one is a team-based exercise known as the Nomadic Brief (Denton, 1998). A "fantasy" context is used: small nomadic groups living off the countryside each of a particular type which the students decide (e.g., warriors, priests, healers). The new students (120 in two groups of 60) are put into random teams of five and walked

into some outstandingly beautiful local countryside (inspiration). Each team must design a sculptural shelter made from bamboo, polythene sheet, and string as in the example in Figure 1. The form of the shelter must also reflect their team type. Team working is used both as a design strategy and to help the year group gel in that by the end of the day students will know four others well and, due to presentations given by each team, they will know something of all those in their group of 60.

Each team completes the design and construction by a deadline. They then give a presentation on their design to the whole group of 60. The group then brainstorms possible assessment criteria. Teams peer assess each shelter on these criteria. Debriefing focuses on team working, design methods, design detail, giving presentations, and assessment.

In subsequent design exercises in year one students produce individual outputs but informal cooperation is encouraged for brainstorming and critical analysis at various stages. Students complete a design analysis exercise in teams and a design exercise where some sections are cooperative and other parts are individual.

#### Year Two

The major team-based exercise in year two involves the design and production of an injection molded device (see Figure 2). Self-selecting teams of four design a small injection molded "useful" product for use as a corporate gift. The teams design the products, make the molding tool, and produce moldings and promotional graphics. This project runs over five weeks at five hours per week involving lectures on injection molding, mold tool design, project management, and costing. Individuals are delegated by the team to attend specific taught sessions and complete specific aspects of the work. The team coordinates these activities and ensures necessary information is pooled to enable the team to progress.

#### Year Three

During year three students pursue major design projects and gain the major-

**Figure 1.** An example of a nomadic structure produced by a team of first-year students.



ity of their degree classification marks. Experience has shown that some students feel they may be disadvantaged if placed in a team with a weaker student or one who may not work as hard (Denton, 1997a). This is an accepted difficulty of team-based work, and so such work is not imposed in year three. However, if students wish to propose a team-based major project, staff consider it. Examples have included a fluid flywheel assisted scooter and a remotely controlled underwater reconnaissance vehicle (see Figure 3). Readers may wish to refer to student portfolios at the department's web pages:

[http://www.lboro.ac.uk/departments/cd/docs\\_dandt/prospectus/undergrad\\_home.htm](http://www.lboro.ac.uk/departments/cd/docs_dandt/prospectus/undergrad_home.htm)

#### Year Four (Postgraduate Certificate in Education)

The aim for this year is to develop the graduates' ability to teach design and technology in UK schools. During the year students complete two long-term planning exercises in the university and others on teaching practice. One of these university-based planning exercises is team based because we believe that team-based planning can have significant benefits.

The team-based exercise uses self-selected teams of four postgraduates to plan a teaching and learning experience lasting between 7 to 12 weeks in a school. Teams have four weeks to produce a scheme of work, lesson plans, visual aids, and exemplar outcomes. In addition to



**Figure 2.** An injection molded product produced by a team of second-year students.

this exercise a session examines approaches to using team-based design work in schools. This is done by working through a team-based simulation called the "NASA brief" based on Ginifer's (1978) work to provide a shared experience as a basis for discussion. The session draws together a number of key factors and approaches that students can apply in their teaching practices during the year.

During the postgraduate year staff also use team-based work to explore the teaching of aspects of design and technology such as mechanisms and structures. Team-based work enables a greater amount of hands-on work to be covered in the time available, it boosts motivation, and it has a significant impact on students. An example is a team-based challenge to design and construct the longest cantilever beam from a one meter square section of wall at chest height using rolled newspaper and thread as structural members (typically teams manage four to six meters). Another example is the use of paper to design a shell structure/mechanism in the form of a human arm that is articulated by thread and can grip a cup (see Figure 4). University-based work on team-based design is then reinforced by students employing these principles in their teaching practices.

#### Issues and Principles

This section examines issues involved in developing team-based

**Figure 3.** An underwater remotely controlled reconnaissance vehicle designed and made by a team of year-three students.



design experiences for pupils. The principles also apply to students training to teach. Within the UK the only guidance given by the National Curriculum is that pupils should be given experience of team-based design work at each Key Stage.<sup>1</sup> This article focuses on Key Stages 3 and 4, but teachers in secondary schools must liaise with primary schools (Key Stages 1 and 2) to establish a logical progression. A long-term plan for building team-based design experiences and competence must acknowledge **basic skills** underpinning such activity. In reviewing a number of authorities on group and teamwork, the author identified the following very basic framework:

- Interpersonal skills: Communications (including drawings)—explaining, clarifying, values; interpersonal sensitivity; general—reliability, reasonableness, cooperation
- Team process skills: Forming teams, establishing norms; procedural and task-oriented behaviors; membership—constructive interaction, encouraging others
- Team and task management: Task decomposition into subtasks; delegation; time management
- Design skills: Group "brainstorming" (mindmapping) for analysis, idea generation, and evaluation

Some authorities emphasize the issue of leadership. However, a focus on cooperative task management can be more useful. Within a cooperative

**Figure 4.** An example of an articulated arm/shell structure made of paper by a team of postgraduate teacher trainees.



approach the team may find that individuals are able to offer leadership at different points, depending on expertise as well as personality. Recent work by Austin et al. (2001, section 3.1.4) with designers in civil engineering supports this notion of flexible leadership.

Basic interpersonal skills can be developed in most design and technology learning contexts and do not require specific team-based work. For example, pupils may be encouraged to act in informal groups when brainstorming and discussing and evaluating individual work. Garner (2001) emphasised the importance of sketching as a communication tool for designers and not simply as a recording/design tool. Stumpf and McDonnell (2002) provided a discussion on the role of “argumentation” in the early phases of design episodes. While they were referring to professional designers, there are some interesting points for educators to consider. Developing pupils’ basic interpersonal skills underpins subsequent team-based design skills.

Team process and team and task management require pupils to experience team-based work rather than only cooperative work. Pupils must gain experience of forming teams, establishing norms, coordination, encouraging others, and ensuring delegated work comes together as a whole. Experience can assist pupils in managing the stages of “forming, storming, and norming” prior to “performing” suggested by Tuckman (1985) above. Similarly, student teachers need to experience team-based design

work and analyze the process in order to be able to manage the process with pupils. It is important that staff manage the team-based learning process so that pupils gain success. Failure in a team task (i.e., the task is not completed by the deadline) can be difficult for pupils and lower their self-esteem.

A survey of team-based work in undergraduate engineering design at a number of UK universities (Denton, 1997b) showed that, when briefing teams, staff focused on task-related objectives only and failed to promote team skills as learning objectives. This is an important point: staff, whether at a university or a school, need to make team process objectives as clear in planning and briefing/debriefing as the subject-based learning involved. To develop team-based design skills staff need to establish a long-term strategy based on a number of learning experiences. Experiences can be structured around task, time scale, team selection and size, support, and assessment. Each element must be considered in relation to incremental progression over time.

**Task:** The task must be suitable for team-based design at the age range being considered. Around a shared core, sub-tasks can be delegated to individuals or subgroups. Different subgroups may form, act, and feed back at various times. Increased scale and complexity can improve motivation as the final outcome has greater impact. An example, at age 11, might be a puppet show, possibly planned in coordination with the English department. The team designs the overall show/theme. Individuals or subgroups are delegated to produce various puppets, the stage, equipment, or effects: together the impact can be impressive.

Team-based design work may be based on tasks supplied by industry. There are indications that pupil motivation improves when working with industry (Denton, 1992). Success in such pupil-valued work can promote self-confidence. Such tasks tend to be high profile and can promote the subject in a school. Design and technology teachers in many countries complain of low sub-

ject status: a well-planned team-based design project based on an industry-led topic can be powerful in developing positive status.

Team-based design can also be developed by simple “micro-tasks,” for example, the development of team-based brainstorming skills in year 7 pupils via sharp five-minute sessions over a series of lessons. For the first five minutes of the lesson the concept of team-based brainstorming is introduced with the classic exercise “how many uses for a brick?” (DeBono, 1982). The exercise is debriefed, the class is “warmed-up,” and then the normal lesson continues. In subsequent lessons the class is put back in the same or different teams and asked to quickly brainstorm other contexts, for example, uses for a clothes peg or ways of fitting a lid to a wooden box. The class is debriefed each time, showing techniques such as noncritical acceptance of ideas in a brainstorm and branching a brainstorm diagram. Similarly, staff can focus on interpersonal aspects. These exercises can be repeated with other year groups using brainstorming tasks pitched at appropriate levels.

Another commonly used approach to team-based design is the “egg race.” These are more abstract tasks, typically involving teams designing a vehicle to carry a raw egg over a specific course using materials such as balsa wood, wire, and rubber bands.

**Time scale:** Team-based design skills can be, partly, developed in tasks lasting minutes, as above. Increasing the scale to one lesson, staff may consider team-based production line simulations. Examples include designing the most efficient way of assembling identical vehicles made from Lego kits or producing a series of identical paper airplanes (recycle used paper). These simulations usually involve a period of team discussion and experimentation followed by a five-minute production run. This is analyzed and improved for a second iteration and possibly a third. The class must be debriefed in relation to both the production line design and the team work aspects.

For longer term team-based projects staff should be particularly aware of Tuckman’s (1985) stages of forming, storming, and norming before teams start to perform. Because longer time scale projects are usually more complex and, typically, require a stage of clarification, this important stage typically happens when a new team is in the storming stage and far from productive. This problem can be minimized by some form of warm-up before the main task begins. As indicated above, experience of forming teams and team-based design can assist in progressing through the storming and norming phases more quickly.

**Team selection and size:** In terms of progression the simplest strategy is self-selection by pupils; the most sophisticated is to “socially engineer” teams; that is, staff select membership on the basis of factors such as balancing abilities, gender, or culture. Between these we may have teams selected on a random basis, typically position in a class list. Random methods may have hidden effects: pupils with surnames beginning with A frequently work together and this can also lead to pupils with common cultural surnames finding themselves placed in teams together.

Self-selected teams, once through the possibly traumatic process of selection (e.g., individuals not wanted by any team), tend to be more harmonious (Perry & Euler, 1988). Such teams are usually of similar backgrounds, for example, gender, ability, or interests. However, such teams may lack a range of perspectives that would assist in idea generation (Hackman, 1983). Bradshaw (1989) observed that teams composed of high intellect members do not always perform as well as heterogeneous teams because members tended not to accept alternative views and argued strongly for their own ideas.

Staff-selected teams may be less harmonious but offer a better range of perspectives. Harmony does not equate to good performance. Experience shows that if pupils are briefed careful-

ly on the value of learning to work with people outside their friendship group they tend to accept the position. There are indications (Bennett & Cass, 1988) that when making up teams staff should avoid creating an unsupported minority. An example would be one boy with three girls; better, two boys and two girls.

Small teams are easier for younger pupils; handling interpersonal aspects and design decision making is easier. Once pupils have gained experience in smaller numbers staff should work towards pupils being able to work productively in larger teams selected specifically to mix ability, etc. The size of a team should match the task: enough work to delegate and ensure all members can contribute. Large teams working on simple tasks risk individuals drifting off-task. Experience shows that teams larger than seven, in a school, can lead to coordination problems. This is probably a sensible limit even for experienced pupils. It is, however, possible to have a whole class as a team if staff act as leader and coordinate the activity.

**Support:** Team-based work can be very threatening for some pupils. Staff need to exercise their knowledge of individuals in setting teams and supporting them. One advantage of team-based design is that staff will find that they spend less time responding to requests and have more time available to observe individuals and teams in action and intervene selectively.

On longer projects, particularly when teams are “socially engineered,” staff need to plan warm-up exercises to support the teams in the initial phases. Warm-up exercises may take a number of forms: introductions by individuals who describe their interests and expertise or short team-based exercises lasting a few minutes enabling analysis and iterative improvement.

The biggest issue for the teacher is ensuring success for each team, that is, a suitable outcome is achieved by the given deadline. This requires consider-

able skill in handling team-based project work. Those with little experience of such work would be advised to start with simple exercises and team selection techniques and build experience iteratively.

**Assessment:** Assessment is probably the biggest difficulty for staff in managing team-based design work. In the UK examination boards often state that team-based projects are acceptable providing staff can identify who did what. This demonstrates ignorance of the nature of team-based design work. For example, when designing one member will often act as “scribe” while others make verbal suggestions. There may be no hard evidence of design thinking other than by the scribe who, in fact, was primarily noting points made by others.

Assessment of team-based design work requires a pragmatic approach: mark the team outcome as a whole and award identical marks to each individual. Simplistic, but consider:

- Team-based design is an approach that is not used all the time. Staff have many other assessments on which to base an individual’s overall grading.
- When setting up teams it is important that pupils know how work will be assessed at the start and it is made clear that they must manage the team to ensure all contribute. A series of progress meetings in which delegated tasks are minuted can be very valuable training.
- Staff may mark the outcome as a whole and then apply an individual weighting according to their observations of workload or achievement.
- In evaluating the project it is possible to use a profile form to focus the members of the team on their performance and then ask the team what weighting they would give to each member. In most cases this will be equal, but not always. Staff will have to monitor this carefully. Hodkinson and Patel (1995), working with engineering undergraduates, considered such peer assessment com-

pare well with that of academic staff. This may not be as close with pupils in schools, but it can be valuable evidence for staff in making decisions.

### Summary

Team-based design approaches are becoming prevalent in industry for good reason. If managed correctly, they appear to bring better results in terms of the speed and quality of the product and the quality of the working relationships. It is hardly surprising that industry is pressuring universities and schools to develop team-based work skills and experience. In addition, there is a good deal of evi-

dence that team-based work can promote learning as well as offer prevocational experience of teamwork.

This article presented some of the ways in which the Department of Design and Technology at Loughborough University approaches training teachers to manage team-based design and to plan for the development of team-based design skills and experience in a secondary school. The issue is complex, but the potential rewards in terms of learning are worth the effort. The major issue preventing some school staff from adopting such approaches is that of assessment. There

are no easy answers, but to fail to develop team-based experiences because of this would be a serious abdication of responsibility. Rather than focusing on assessing only the easily assessable, we must look more broadly at a pupil's ability to design. One important feature of that is how that pupil is able to integrate and cooperate with others in team-based design work.

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### Notes

<sup>1</sup> Key Stages: 1 = ages 5-7, 2 = ages 7-11, 3 = ages 11-14 and 4 = ages 14-16. Ages 16-18 are noncompulsory in the UK and are not covered by the National Curriculum.



## Improving International Project Success

Kurt H. Becker and Gary Stewardson

There are numerous elements necessary for developing nations to transition into the world economy and raise the standard of living of their citizenry. One element is a skilled workforce. Countries looking to develop a skilled workforce often look for assistance from other countries. International expertise and resources come through projects funded by world loans or through economic aid from developed countries. "Vocational and technical education play important economic and social development roles" (Herschbach & Campbell, 2000, p. 19) in the international development process, and opportunities are available for professionals in the field of vocational and technology education with attributes to assist the international development process. Taking advantage of these opportunities enables those in the profession to gain international recognition for themselves and for the discipline, to assist underdeveloped nations in technological development, and to reap the financial rewards of international consulting.

Various vocational training projects are employed throughout the world, each

utilizing models with varying degrees of success. Factors that affect the success of projects within these countries include (a) a comprehensive model to meet the needs of the country and (b) international and domestic consultants with attributes to facilitate the model. How these factors are used to enhance the success of vocational training projects is illustrated in the following.

### Comprehensive Model

For a project to be successful a comprehensive model must be utilized to meet the needs of the host country. When properly designed and orchestrated, the model can produce quality outcomes and have a tremendous positive impact on the progress of a country.

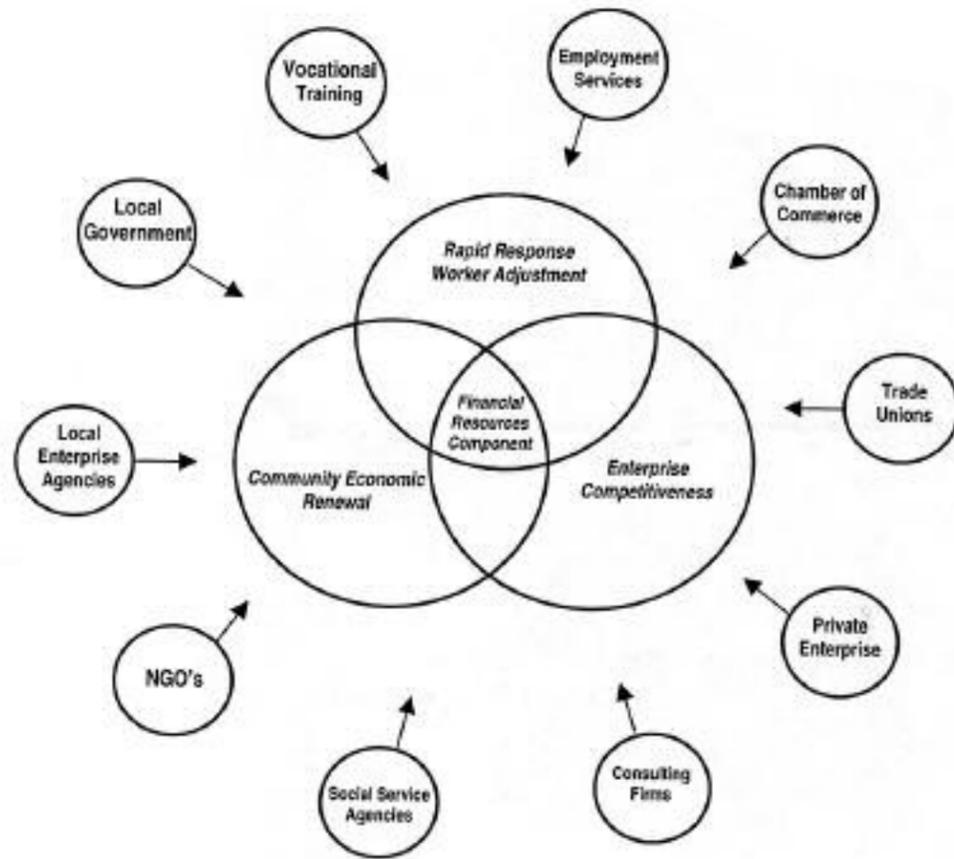
With the fall of the Soviet Union, there has been a need for the development of economic and technical training programs in Central and Eastern Europe. The U.S. Department of Labor (USDOL), through the U.S. Agency for International Development (USAID), has implemented several development projects in this area.

Experience gained during the early 1990s by USDOL technical assistance experts working in Central and Eastern Europe to help workers and communities severely impacted by economic restructuring led to the development of a comprehensive adjustment model or strategy comprised of four components. This model has proven successful over the past few years. Figure 1 illustrates the model that is achieving success in the region. The objective of this strategy is to reduce the serious worker and community adjustment problems caused by the privatization and restructuring of state-owned enterprises. When governments adopt this model and use it in a systematic and integrated manner with other active labor market measures, it reduces the economic and social costs of adjustment, shortens the time required for training, and facilitates the transition to a market economy (USDOL, 1998).

The USDOL adjustment model is comprised of the following four components:

- **Rapid response worker adjustment component** to plan, organize, and facilitate the transition of workers to new jobs.

Figure 1. USDOL model.



- **Community economic renewal component** to stimulate local economic development efforts and generate new jobs in communities impacted by enterprise restructuring.
- **Enterprise competitiveness component** to strengthen surviving enterprises and preserve jobs.
- **Financial resources component** to provide funds to implement the worker, community, and enterprise adjustment components.

#### Rapid Response Worker Adjustment Component

The rapid response worker adjustment component is implemented by a small group of highly skilled industrial adjustment (IA) specialists who function as a rapid response team. IA specialists facilitate the timely organization and implementation of a systematic worker adjustment process in enterprises and communities undergoing economic restructuring. They work with restructur-

ing state-owned enterprise managers and worker representatives to develop and implement plans to provide adjustment services and programs in order to transition large groups of workers to new employment as quickly as possible. In addition, they provide technical assistance to help develop and implement effective community economic renewal and enterprise competitiveness strategies.

Whenever possible, IA specialists work with state-owned enterprise managers and function as the primary mechanism to:

- Conduct surveys to determine worker needs.
- Plan and organize “in-plant” pre-layoff services.
- Establish an outplacement or resource center in the plant if one is needed.
- Arrange for the delivery of pre- and post-layoff employment and training services to workers being dis-

placed, including job search training, job development, job placement, self-employment help, vocational counseling, retraining, financial planning, remedial education, entrepreneurial training, and other forms of employment assistance.

#### Community Economic Renewal Component

The community economic renewal component of the USDOL adjustment model helps communities and regions experiencing restructuring, downsizing, or enterprise closures to develop and use a systematic business growth, job retention, and job creation strategy to begin or expand local economic development efforts.

IA specialists work with government, business, and labor leaders in communities experiencing economic restructuring and privatization to help them better understand the essential local economic development principles and processes

required to revitalize their economies. Implementing the community economic renewal process creates a new sense of “community” and direction in the face of serious economic threats.

#### Enterprise Competitiveness Component

The enterprise competitiveness component helps state-owned enterprises undergoing restructuring and downsizing, as well as other business enterprises in the impacted communities or region, to become more productive and competitive in the global economy. Healthy enterprises provide more secure jobs for their managers and workers and generate additional jobs in the community.

IA specialists help communities and enterprises accomplish these objectives by providing information to enterprise management and worker representatives about innovative techniques and programs that can be made available to help them strengthen their enterprises, by helping them to assess their situation, and by arranging for or delivering specific enterprise competitiveness training and technical assistance services. The enterprise competitiveness component is an integrated approach that includes five essential elements:

1. **Upgrading workers’ skills** by aiding restructuring state-owned enterprises and other enterprises to help increase their competitiveness or expand their operations by using Quick Start training to upgrade their existing workers’ skills or to train new workers.
2. **Improving labor-management relations** by providing Training for Partnership and Interest-Based Problem-Solving workshops that teach managers, workers, and union officials in affected enterprises and communities the techniques that can be used to solve problems, build cooperative partnerships, and generate high-performance workplaces.

3. **Increasing productivity and reducing costs** by helping restructuring enterprise managers and their unions to establish plant-level productivity improvement and cost-saving projects to reduce costs and increase productivity.

4. **Improving human resource utilization** by helping restructuring enterprises to develop and implement strategies that improve human resource utilization to preserve jobs.

5. **Maximizing joint competitive advantage of small enterprises** by assessing the need and opportunity for interfirm cooperation and collaborative networks of small companies in communities or regions to help them maximize their joint competitive advantage in the global marketplace.

#### Financial Resources Component

The financial resources component provides the money to pay for adjustment components. The financial component can be organized and implemented in several ways:

- USAID funds that are allocated for adjustment projects in countries are normally placed under the control of the USDOL Worker Adjustment Project.
- Salaries of IA specialists and operating costs of IA teams are normally provided by the government from funds budgeted to the ministry of labor, employment service or national labor office, or through other appropriate agencies.
- Some resources may also come from the proceeds of grants or loans provided by international agencies and donors (USDOL, 1998).

The USDOL model has proven to be successful because it utilizes components that focus on a structured involvement from communities, worker adjustment to prepare for market changes, enterprise competitiveness to stimulate the workforce, and strategic funding. All of these are necessary to produce gains to the host country.

The enterprise competitiveness component of the USDOL model addresses vocational training and uses IA or “Quick Start” specialists. These specialists or consultants work with employers and training organizations to design Quick Start training programs that provide specific upgrade or skill training for existing workers or unemployed workers who will be hired to meet the needs of business. Quick Start is a short-term training or retraining program that is specifically designed for new, expanding, or restructuring companies that must retrain their workforce because of changing products, technology, or production processes (Hansen, 2001). Short training schedules mean that an enterprise receives a quicker return for its investment, as do employees and the agency providing the financial resources.

The seven steps involved in developing a Quick Start program consist of:

- Establishing a labor office/business/training linkage.
- Implementing a systematic training development process.
- Developing training curriculum and materials.
- Selecting and training instructors.
- Recruiting, screening, and selecting trainees.
- Conducting skill-training program(s).
- Evaluating the results.

Following this procedure produces an effective result for vocational training. Professionals of vocational and technology education are well suited to engage in a component such as this because of a strong background in vocational curriculum development and a well-rounded technical expertise in various trades. To date, several countries in Central and Eastern Europe have successfully implemented Quick Start including Poland, Bulgaria, Hungary, and Macedonia. In Poland Quick Start has been successfully used in the coal mining industry. As the mining industry started closing facilities because of the reduced demand for coal, displaced workers needed training in other fields and miners who were not

being displaced needed cross training in other areas of mining. The Quick Start system was used effectively to cross-train mining workers in a reduced timeframe giving the industry the flexibility to better utilize the existing workforce. In Bulgaria it has been used in the textiles, machining, and automotive industries. In Hungary it has been used in the printing industry, and in Macedonia it has been used in the computer design, textiles, and publishing industries.

### Consultant Attributes

In addition to having a model that proves to be successful, another factor that affects the success of international projects is using international and domestic consultants who possess the attributes necessary to implement the model. Consultants play a vital role in determining if project goals are met. International and domestic consultants work together to facilitate the model within a country, each having specific jobs related to the project.

### Consultant Barriers

The international consultants have many challenges because the transfer of successful vocational training systems from one culture to another is not a simple task. There are a variety of barriers that exist when facilitating international projects; in fact, barriers exist within every culture, some obvious and others not so obvious. Making matters more difficult, the barriers change with each country and sometimes within regions of the same country. It is important that an international consultant be aware of barriers that include (a) language, (b) resistance to change, (c) sustainability, and (d) culture.

*Language* is an obvious barrier if you do not speak the language of the host country. Language as a barrier is the case in many situations. Translators/interpreters assist with the language barrier. Professional translators/interpreters not only make the international consultant understood, but assist with organization and dissemination of information. Additionally, they assist the international consultants with the flow of the training

and facilitate activities during the training. International consultants should establish a good working relationship with the translator/interpreter.

*Resistance* to change is another barrier that is obvious, but often ignored. It is human nature: People tend to resist change. Wilson (1992) stated that nobody changes unless the pain is intolerable or the gain is overwhelmingly attractive. Consultants working on international projects must communicate the benefits of change to the host country and play an important role in promoting the change necessary to make the project successful and sustainable.

*Sustainability* is the mark of a successful project. Sustainability requires the local people to embrace change and the practice of new techniques. The international consultant from the first day on the job must continuously review the methods used for sustainability for any given country. Sustainability tends to be one of the most difficult obstacles or barriers for an international consultant. The international consultant must map out a clear plan to the domestic personnel.

*Culture* is a barrier that may be less obvious to the international consultant, but is still important and must be identified. Having knowledge of cultural differences is important for an international consultant. An example of a simple cultural barrier that cannot be ignored is one that surfaces during training. The consultant should be aware that in some cultures there is a need for extended breaks. Training in Western culture acknowledges short breaks (10 to 15 minutes) while in other cultures longer breaks are preferred (30 minutes). In our Western culture we usually take lunch at 12:00 noon and other cultures take a large meal at 1:30 p.m. This slight change in the training format can assist in keeping the trainees comfortable and happy during the training and allow the message of the consultant to be accepted.

### Overcoming Barriers

Understanding that barriers exist is critical for international consultants to be

successful. To overcome barriers that exist when facilitating international projects, consultants should exhibit certain traits and skills. These include:

- Being able to customize a model.
- Understanding the culture.
- Implementing a data collection system.
- Being able to establish articulation between consultants.

One of the most important traits that an international consultant should exhibit is the ability to customize a model to meet the needs of the host country. Consultants many times overlook this process as they assume that the model used in one country will work in other countries or locations. This is simply not the case. Many times the existing model needs to be modified. Subtle changes in the way the model is orchestrated can mean the difference between success and failure. Customizing a model to a specific country's needs may involve working closely with a domestic consultant. A domestic consultant can assist to determine what changes will and will not work. The domestic consultant may assist in identifying local personnel who can effectively contribute in leadership positions and give perspective and understanding to the current economic conditions of the country. Domestic consultants should work closely with international consultants to identify critical infrastructure needs and jointly facilitate the process. The international consultant needs to have a strong tie to the domestic consultant. When a host country provides a domestic consultant, there needs to be constant articulation between the domestic and international consultants.

Another trait that successful international consultants exhibit is the ability to learn about the culture of the host country. The translator/interpreter can assist with learning some basic language of the country. This can include simple greetings and words related to the project or training within the project. Learning about a country's history, customs, food, etc., is useful because it will not only give information that will aid in understanding

the culture, but also will stimulate further dialog and build trust. Consultants are more likely to have success with an increased understanding of the culture.

The ability to implement a comprehensive data collection system is another important trait that international consultants should exhibit. When a quality system is in place and administered properly, the aid country and host country can both see tangible outcomes. The data collection system should have a clear design that can be effective, be able to collect comprehensive data, and have an evaluation component to monitor the results. This requires collecting data at the outset of the project and continuing throughout the entire project. With a system in place, monitoring successes and/or failures can be done. The system can determine if the project is performing as it is supposed to, when it is getting off track, and what corrective measure should be implemented to get it back on track. It is extremely important that the data collection system involve the international consultant working directly with domestic consultants at the national, regional, and local levels. Each party should have a clear vision as to how the results of the data are used and the benefits to the host country.

Another trait that international consultants should exhibit is the need to articulate with domestic consultants at the

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national, regional, and local levels. Project success is magnified with articulation between the groups. There are several reasons why articulation is important. As stated earlier, cultural change is slow. Without a direct hands-on relationship, the domestic consultants may not fully recognize the value-added benefits of the project. It is important that the domestic consultants understand the benefits and are motivated to continue the work in progress once the international consultants withdraw from the project. The domestic consultant is a link to enhance project success and sustainability.

Vocational and technology education professionals are in a unique situation when it comes to international development since there is the need for technical training in underdeveloped countries throughout the world. As vocational and technology education professionals become involved in international projects, it is important that certain traits are utilized. Perhaps the key to being a successful international consultant is to be sensitive to possible barriers and be flexible and willing to modify the process as needed. In addition, using an effective model with consultants that have the necessary attributes to assist in project success is required. Each project brings with it a unique set of circumstances and it is important to realize the following:

- International consultants play an important role in the overall facilitation of a project.
- International consultants give direction to the project and oversee modifications to the proposed model; their leadership is imperative.
- Domestic consultants should be involved to increase articulation at various levels of project organization.
- Project sustainability requires articulation with domestic consultants.
- The Quick Start model has proven successful in many countries.
- Using a model with the components of the USDOL model can promote success within the project.

International consulting is an exciting part of the vocational and technology education discipline and can prove very rewarding for those who participate. As professionals in the field get involved, this will assist in promoting the discipline in a positive light and open new doors to other cultures.

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## Selected Factors of Teaching Effectiveness: Perceptions of Apprenticeship Trainers

Howard R. D. Gordon

It is theoretically impossible to measure a teacher's effectiveness by measuring only student achievement (Biddle & Ellana, 1964; Medley, Coker, & Soar, 1984). There is no scientific method of separating what and how much a pupil learned from the teacher, due to all other extraneous list of traits attributed to the teacher (Sikora, 1997).

Kindsvatter, Wilen, and Ishler (1988) addressed seven assumptions and beliefs basic to effective teaching:

- The quality of teaching is directly contingent upon the quality of the decision making that precedes that teaching.
- Teaching is a complex behavior.
- Teaching is a learned behavior.
- Instruction should be based on the most effective strategies, methods, techniques, and behaviors as determined by current research and learning.
- Students must be motivated.
- The social settings in which instruction occurs is a major factor affecting that instruction.
- Teaching in the final analysis is a personal invention.

The results of teaching have been studied in terms of student achievement, adjustment, attitudes, socioeconomic status, and creativity (Nwagwu, 1998). Despite all these activities, no studies have examined the factors underlying teaching effectiveness as perceived by apprenticeship trainers.

Under a proposed five-year strategic plan for the new federal workforce development law, the U.S. Department of Labor aims to increase by 10% the total number of registered apprentices and the number of women in such programs. The plan, which outlines the department's vision for the 1998 Workforce Investment Act (WIA) from 1999 to 2004, proposes to increase the number of individuals in registered apprenticeship

programs from 415,262 to 458,482 over five years. It also targets to increase by 10% (from 8,748 to 9,897) the number of women in such programs by 2004 (Dembicki, 1999).

The current emphasis on educational reform in our nation's schools should be forcing us to examine the underlying factors of teaching effectiveness. As work and technology issues increase, apprenticeship trainers must be effective in preparing apprentices for their future roles in selected allied trades (e.g., industrial painting, wall covering, dry-wall finishing floor covering, glazing, sign painting).

### What We Sought to Do

The following objectives guided this investigation:

- To identify factors underlying apprenticeship trainers' perceptions of teaching effectiveness.
- To describe the level of importance of teaching effectiveness as perceived by apprenticeship trainers.
- To determine if significant differences existed in mean scores among four groups of apprenticeship trainers' perceptions toward selected factors of teaching effectiveness.
- To compare perceived level of teaching effectiveness of apprenticeship trainers by age groups.

### How We Proceeded

The target population was apprenticeship trainers of allied trades from all 50 states and Canada. The accessible population for this exploratory study consisted of apprenticeship trainers ( $N = 306$ ) who attended the annual International Union of Painters and Allied Trades (IUPAT) four-day seminar at Marshall Community and Technical College during the summer of 1999. A registration list of the four-day event was obtained from Marshall Community and

Technical College and served as the frame for the study. The apprentice trainers who comprised the population of the study were operationally defined as prospective trainers of trainers.

According to Krejcie and Morgan (1970), a sample size of 169 is needed to represent a population of 306 when a simple random sample is drawn. However, Tatsuoka (1982) cautioned that when stratified samples are used rather than simple random samples, smaller samples should be drawn to more accurately represent the population because the design effect is less than one for stratified samples. Therefore, the sample size recommended by Krejcie and Morgan was reduced from 169 to 150 and was drawn as a proportionally stratified sample composed of 48 first-year apprenticeship trainers, 45 second-year apprenticeship trainers, 30 third-year apprenticeship trainers, and 27 fourth-year apprenticeship trainers.

A two-part questionnaire was developed by the researcher. The first part of the instrument asked participants to determine their perceptions of teaching effectiveness.

A 5-point Likert-type scale was used (1 = *not applicable*, 2 = *unimportant*, 3 = *important*, 4 = *very important*, and 5 = *essential*). Muller (1986) stated that using a scale with a middle category seems to work as well as a scale without a middle category. The second part of the instrument asked participants to provide pertinent demographic information.

Content and face validity for the instrument were established by a panel of experts consisting of university faculty, community college administrators, and business and industry personnel. Fourteen purposely selected adult and technical education graduate students served to establish reliability of the ques-

tionnaire. The resulting Cronbach's alpha reliability coefficient for internal consistency was .8817.

The instrument was administered by the coordinator of the seminar on the third day of this four-day event. However, this time period of administration proved to be less than ideal as indicated by a return rate of only 53% (79) usable questionnaires. Caution is warranted in generalizing the results beyond the accessible sample.

### What We Learned and What It Tells Us

Data were analyzed with the SPSS for Windows computer program. Appropriate statistics for description were used including frequencies, percentages, means, and standard deviations.

Factor analysis (principal components with varimax rotation) was used to identify factors underlying apprenticeship trainers' perceptions of teaching effectiveness. Procedures for conducting the factor analysis were patterned after those of McCaslin and Torres (1992). Analysis of variance was used to test for significant differences among the subsamples of apprenticeship trainers on their perceived factors of teaching effectiveness. When significant differences were observed, the Duncan's multiple range test was used to identify where differences existed.

The data on apprenticeship trainers indicated that a majority (89.9%) of the respondents were male, 10.1% were female. This finding is supported by data reported by Dembicki (1999). According to Dembicki, the U.S. Department of Labor aims to increase by 10% the total number of women participating in apprenticeship-related areas.

The characteristics collected from apprenticeship trainers also revealed that over 30% fell within the 35 and 45 age brackets. In addressing the educational level, almost two thirds (62.0%) of the apprenticeship trainers reported having completed college credits beyond the

high school level. Apprenticeship trainers reported an average of 16.26 years of employment ( $SD = 9.54$ ) in their current or most recent occupation.

To discern whether there was clustering among the items, the ratings of respondents were subjected to factor analysis (principal components with varimax rotation). The analysis resolved the 51 items into 10 factors including a dominant one that accounted for over two fifths of the total variance explained. A factor is a set of individual questionnaire items that coalesce into an entity on the basis of their intercorrelation, presumably on the basis of their conceptual similarity.

The 10 factors accounted for 70.7% of the total variance. Factor loadings ranged from .51 to .81. According to Hair, Anderson, Tatham, and Black (1998), loadings of .30 are to be considered significant; loadings of .40, more significant; and loadings over .50, very significant. As indicated above, it is presumed that factors are held together by an underlying theme or concept. This underlying theme provides a basis for their naming. In order of percentage of variance explained, the 10 factors in this solution were named as follows: faculty-student interaction, classroom management, professional development, enthusiasm, students participate in evaluation, socialize with students, procedures and policies, positive individual attention, communication and feedback, and atmosphere for respect.

Examination of the faculty-student interaction factor indicated that it was dominant, explaining 29.7% of the variance. It was also revealed that the items in this factor, for the most part, refer to a process of encouragement and involvement of students in learning activities. In the survey of people nominated for the 1999 All-USA Teacher Team, respondents reported that interaction with students and influence of students' lives ranked highest among items that teachers found to be rewarding about their jobs (DeBarros, 1999).

The remaining nine factors each explained relatively small amounts of variance. The atmosphere for respect factor was comprised of a single questionnaire item. In a strict sense, a single item cannot constitute a factor. However, "respect" for apprenticeship trainers must in this context be taken as a special case—an important outlier. The fact that it did not correlate with other questionnaire items did not diminish its value. Indeed, this item had a factor loading of .79, *very significant*, and virtually the highest among the 51 questionnaire items. DeBarros (1999) reported that, in general, students respect teachers.

Apprenticeship trainers agreed that it was *very important* ( $M = 4.50$ ,  $SD = 0.73$ ) for instructors to be at all scheduled classes. Respondents were more likely to agree that it was unimportant ( $M = 2.65$ ,  $SD = 0.98$ ) for students to assist in composing test questions. Almost three fourths (72.54%) of the items were reported as important ( $M = 3.01$ -3.97) by respondents in this study.

Significant differences were observed among means on 6 of the 10 factors of teaching effectiveness. Duncan's multiple comparison test was used to determine the nature of difference among the four groups of apprenticeship trainers. This analysis revealed that first-year apprenticeship trainers were significantly different from fourth-year and third-year apprenticeship trainers on the faculty-student interaction factor. The data also revealed that first-year apprenticeship trainers were significantly different from third-year and fourth-year apprenticeship trainers on the communication and feedback factor. Second-year apprenticeship trainers also reported a similar pattern for the communication and feedback factor. Communication and feedback are essential tools for helping students understand cognitively what they are doing, what they should and should not be doing, and what adjustments should be made (Rink, 1993).

Apprenticeship trainers from the four different groups did not differ significantly on the following four factors: pro-

professional development services, participation of students in the evaluation process, socialize with students, and atmosphere for respect.

Significant differences were observed among means on 5 of the 10 factors (classroom management, explanation of procedures and policies, professional development, communication and feedback, and atmosphere for respect) of teaching effectiveness by age groups.

Apprenticeship trainers within the 35 to 44 age bracket were significantly different ( $M = 22.67$ ,  $SD = 4.05$ ) from apprenticeship trainers in the 45 to 54 age group ( $M = 24.77$ ,  $SD = 3.25$ ) on the classroom management factor. This finding suggests that apprenticeship trainers within the 45 to 54 age bracket were more likely to have higher mean ratings for classroom management. This finding can probably be attributed to experience within the apprenticeship industry.

The data revealed that apprenticeship trainers who fell within the 25 to 34 age group were less likely to have high mean ratings for the 10 factors of teaching effectiveness when compared with the other age groups.

Based on the results of this study, the typical apprenticeship trainer in this study (a) was more likely to be a male, (b) was more likely to be in the age bracket of 35 to 54 years old, (c) had completed some college credit hours, and (d) had completed an average of 16 years of employment in current or most recent occupation.

In this study, apprenticeship trainers were more likely to report the following statements as *very important* for teaching effectiveness:

- Be at all scheduled classes.
- Be fair and impartial in dealing with

requests.

- Show enthusiasm for students and subject matter.
- Listen to students' opinions and comments.
- Be specific about acceptable and unacceptable behavior.
- At the beginning of class(es), state topics and objectives.
- Give appropriate and considerate responses to questions.

These findings illustrate the importance of these statements as measuring indicators of teaching effectiveness for apprenticeship trainers.

Third- and fourth-year apprenticeship trainers were more likely to report higher mean ratings for the 10 perceived factors of teaching effectiveness when compared to first- and second-year apprenticeship trainers. This finding can probably be attributed to the amount of in-service training completed by third- and fourth-year apprenticeship trainers.

The following perceived factors of teaching effectiveness were highly significant among the four groups of apprenticeship trainers: communication and feedback, faculty-student interaction, and explanation of policies and procedures. The data seem to suggest that communication and feedback, faculty-student interaction, and explanation of policies and procedures are essential factors for assessing teaching effectiveness of apprenticeship trainers. Overall, younger apprenticeship trainers appeared to be less aware of the essential factors of teaching effectiveness.

The following implications and recommendations are offered:

There was not a representative sample of female apprenticeship trainers in this study. This implies that there is a need to recruit and retain more female

apprenticeship trainers. To increase participation, apprenticeship agencies should develop and circulate awareness and education materials to community-based organizations.

Apprenticeship trainers rated almost three fourths of the 51 items as *important* for an instructor to practice. This finding suggests that apprenticeship trainers value a majority of these selected measures of teaching effectiveness as essential for evaluation and assessment of apprenticeship trainers.

First- and second-year apprenticeship trainers were more likely to report low mean ratings for the 10 perceived factors of teaching effectiveness. This probably implies that these two groups have not received sufficient training in the area of teaching effectiveness. Preservice training should therefore be made available to prospective apprenticeship trainers in the area of teaching effectiveness. Mentoring should be provided for incoming and younger apprenticeship trainers.

Research should be conducted to determine the relationship between teaching styles and teaching effectiveness of apprenticeship trainers.

Improving teaching effectiveness is not merely a function of effective reward system, but rather a collaborative function of several factors working together to improve not only what goes on in the classroom but to improve quality of faculty. Apprenticeship trainers must learn a body of knowledge essential for teaching, how to prepare for instruction, and how to deliver instruction to become effective.

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## Editor's Pages Making Technology a Major School Curriculum — Part 2

Jerry Streichler

An earlier statement on this topic (Streichler, 2002) took a provocative stance. It remains a matter of critical importance to all technology professionals (including engineers) and their organizations, all professionals in education, persons in business, industry, and government, and other concerned citizens. Since that first statement was published, ideas continued to be generated in support of the rationale and for implementation strategies. It was thought that these would be useful to respond to readers' inquiries or challenges.

Surprisingly, another very meaningful use for these ideas surfaced in the form of an invitation to give the keynote address at the New York State Technology Education Association's 41st Annual Conference this coming spring. The ideas being collected and the material in the first statement are strikingly appropriate to the conference theme: "Technology Education: A Core Subject." Thus far it has been pleasing to consider that the stimulating, challenging, and motivating ideas will be included in a presentation that will attempt to include uplifting and positive notions about the listeners' chosen profession and about themselves.

These ideas are offered as a sort of preview of a provocative and challenging issue. Obviously, they are not in the final presentation format and they provide more information than is likely to be in that presentation. The reader is invited to come along on this "trial run" for the keynote address. While this material can stand alone, some readers may wish to read the 2002 first statement. Also, even for those who have read it, revisiting *Technically Speaking: Why All Americans Need to Know About Technology* (Pearson & Young, 2002) will provide a meaningful context for what follows here.

### The Importance of Technology Studies

That technology is an important school subject is partly confirmed by recent activities of engineering educators. Creighton (2002) described a number of "innovative" programs that engineering schools have gotten underway to get kids excited about engineering. This is only part of a much broader involvement in the lower schools by engineers.

The foregoing, an aspect of technology

instruction and engineering's interest, represents recognition of the need to include technology experiences in the curriculum. Other components of technology could have been used to make the preceding point, but *engineering* is intentionally used as a device to capture the readers' attention and more will be said in this article about that technique.

Regardless of why the term has been used, it is emphasized that engineering is but one important component of the much broader kindergarten through college technology curriculum.

### No Go?

Technology educators may be tempted to bask in the glow of recent impressive accomplishments and accept small successes of programs in some school systems and states while being resigned to the field's current status in many other states and school districts. Such an attitude may ensure that technology will never assume its rightful place in the majority of school offerings. In fact, that attitude may contribute to an unhealthy erosion of the progress the field has made.

In considering a militant and vigorous campaign to achieve the status that technology deserves, some may respond that this is not the time in the current socioeconomic and geopolitical scene in the United States. Ideas, charged words, and slogans may be invoked to justify inaction such as unemployment, outsourcing, dependency on foreign talent, dearth of citizens preparing for the scientific and technology professions, increasing productivity with minimum job creation, a presidential election campaign, national security needs, and the war on terrorism. Some or all could be used to rationalize the status quo for the technology curriculum.

### Go!

The position here is much to the contrary. The circumstances that those words and phrases suggest may indeed be the foundation and rationale for:

- a militant, self-confident, dynamic posture for the technology curriculum and those who deliver it;
- assuming leadership in research and curriculum studies that deal with the issue of

inclusion of all subjects at all levels;

- making the case that technology studies makes a vital contribution to meeting human and societal needs and matters of national necessity at least equal to that achieved by the other so-called basic subject fields;
- taking the lead in an effort to revolutionize the entire public school curriculum, the college entrance examinations, and college entrance requirements; and
- asserting the leadership and professional skills that exist in state, regional, and national professional organizations, particularly as these issues are in their self-interest. (The International Technology Education Association has demonstrated considerable effectiveness in dealing with issues as discussed here in the past several years.)

Several steps need to be taken to get the job done, but before these are discussed, it is helpful to consider the forces that have influenced the current position of technology instruction in today's schools.

### Changing the Playing Field

It is not an oversimplification that today's school curriculum has not changed much in the past 100 years. If that comment raises eyebrows, what will be the reaction to the notion that the 100-year-old curriculum of the lower schools, particularly of the high schools, echoes curriculum concepts out of the middle ages?

In itself, old is not bad, but this static, slow to change condition has profoundly resulted in stifling, rigid, unresponsive college entrance requirements, which in turn drive the curricula of the lower schools.

In part, that explains the existence of English (or language arts), mathematics, science, and social studies, sometimes referred to as "the Big Four," as the dominating elements of the existing curriculum.

Clearly, there is much to be done to change the situation. But first, it is helpful to consider the forces that have influenced the current position of the technology curriculum in today's schools.

*Curriculum kings (barriers to curriculum reform)* are persons who currently influence the curriculum and who technology educators must be able to identify. To a degree greater than they deserve, these are persons who have achieved success in one or more elements of the Big Four and believe that everyone ought to be required

to experience it in the manner they had and ought to achieve the same level of success. So, when they become leaders in higher education or in school districts, or in other venues in society (such as politics), their values are invoked and are extremely difficult to change.

*Influential universities, entrance requirements, and the college boards* have positions and values that make them curriculum kings (dictators?) of a sort, but with an interesting twist. These folks fail to recognize that although the lower schools remain wed to the Big Four as a consequence of their dictates, the offerings of the nation's higher education institutions themselves evidence an impressive array of options. Many of these institutions now inventory courses and programs, and use names for colleges and departments that better respond to the changing nature of knowledge, technology, and the needs of society. The irony unfortunately is that a corresponding flexibility has not resulted, except perhaps at the community college level, in college entrance requirements. There seems to be no disposition to diminish the emphasis on the Big Four or to introduce alternatives to them for high school graduation, college entrance requirements, and the content of standardized college entrance examinations.

*Can technology educators be their own worst enemies?* Consider the effects upon fellow professionals from other disciplines when technology teachers engage in forms of promotion about their students' work and accomplishments. While pride in what they are doing with students is justified, is it possible that the way the promotion is done achieves just the opposite of what is intended? Might not fellow professionals who are comfortable about their subjects and place in the school curriculum wonder why that crowd in technology needs to engage in that sort of promotion? Consider, also, the possible negative effects when:

- the technology literature unintentionally promotes the difference between "academics" and technology subjects. Might persons outside the field then conclude that technology is inferior?
- it is proudly announced that technology helps students to succeed in mathematics and science. Do persons outside the field conclude that technology is only a helping experience and not a subject that should enjoy equal status with mathematics and science?
- technology educators exhibit "suppliant behavior." Throughout the discipline's history,

and particularly in the current period of budget cuts and threats of program elimination, a great deal of time, energy, and effort is spent justifying the existence of technology offerings. What impression does that make when contrasted with the behavior of professionals who populate the Big Four whose status and stature precludes such behavior and who have rarely, if ever, needed to plead to have their subject recognized and respected?

### A Think Tank (Can a Good Idea Come from USA Political Parties?)

There is a constellation of ongoing good works and efforts to improve and secure the place of technology subjects in the schools. Most are conventional in nature. Here are some thoughts and approaches that may be less conventional, but equally effective, in achieving the important goal.

George Lakoff (as cited in Powell, 2003) tells us that the Republicans have two think tanks and the Democrats have responded with one of their own. In part, they draw upon such disciplines as linguistics, cognitive science, and the neurosciences, in addition to political science.

A think tank for technology ought not be unthinkable. It could draw upon those same disciplines within an overlay of other education disciplines. It goes without saying that it should be supported by the broadest possible consortium of the professional associations devoted to technology education in all its manifestations—general and occupational education, from kindergarten through postdoctoral levels. Its overall purpose would be to establish technology in the schools as envisioned here and could undertake to:

1. Work with university programs to focus at least some of the research of technology PhD programs on:

- instructional techniques and curriculum organization for effective learning in shorter time (results may tell that technology can take an equal place in the curriculum with the other basics included in the Big Four);
- the efficacy, relevancy of the curriculum of the lower and higher schools in today's society (likely to be a lifelong challenge to technology education researchers);
- the efficacy of the existing curriculum array; and
- the effects of "selling" technology experiences as motivators for learning mathematics, science, and other subjects upon the image we wish to project.

No doubt some of these items will require longitudinal studies and, most desirably, research teams should include nationally known curriculum theorists.

2. Identify the most effective language (terms, slogans, concepts) that could be used to gain the acceptance of the public, political, and educational decision makers. For example, Republicans have effectively imprinted the notion of tax "relief" in the minds of most voters. With think tank help, they have concluded that the word *relief* denotes that there is a sort of an ailment that needs to be cured or remedied. Such notions, effectively communicated, become difficult to dislodge from a person's mind, and to do that it would take an equally effective and (emotional) concept. Aha...could that be the reason that *engineering* was used in preceding paragraphs of this statement? And if it worked, what would it take to make the term *technology* as or more attractive? So, the think tank could undertake considerations of the terms and concepts that technology educators would use to communicate the message about the importance of technology.

3. Formulate and deliver training. Effective use of language is only one of the possible aids that could come out of the think tank that would also translate its findings into training and strategies that deal with such items as:

- technology education and academics—what's the message when these terms are used?
- providing aid to state, regional, national professional organization leaders in proper and effective:
  - ◆ use language and terms;
  - ◆ ways to deal with bureaucrats and politicians (how to lobby effectively?); and
  - ◆ packaging and use of data and reports.

4. And, finally, the findings coming out of the think tank could well provide the proper and effective language to promote what "Leaders on Leadership," (2003) reports about M. James Bensen's use of the term *myth*. Successful organizations and movements have an underlying myth. This term is not used negatively. It connotes such things about an organization or of a curriculum movement, as in the case of technology, the purpose, the good, the benefits, the glow of the products. A think tank entity could provide advice to all members of the profession, from individual classroom teachers to professional organization leaders, on proper and effective behaviors and techniques:

- to make the case for technology or when technology offerings come under threat of

reduction or extinction.

- that avoid the role of applicant because such a role may confirm for decision makers that technology is inferior to the basic courses with which technology strives for equal status?
- to communicate that technology instruction:
  - ◆ manifests one of the most effective learning environments in the schools;
  - ◆ includes subject matter that responds to the nation's and individual needs;
  - ◆ maintains student interest to a high degree;
  - ◆ provides effective exploratory, problem-solving, and creativity experiences;
  - ◆ accentuates activity learning that effectively promotes content mastery;
  - ◆ achieves extraordinarily positive effects on students;
  - ◆ has highly motivating to students;
  - ◆ as one of the historically first to adapt and apply activity, continues to accentuate activity in an affective manner while encouraging creativity, problem solving and mastery of content knowledge and technological capabilities and skills;
  - ◆ is by its very nature a totally relevant subject (several ways to look at that); and
  - ◆ uses methods, historically original and unique, that other disciplines have adopted and adapted.

5. What are the things that can be embedded in the minds of citizens, politicians, and education bureaucrats and will work toward the establishment of the technology curriculum? Could it be *all* that good stuff enumerated above

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communicated within a theme with the following "charged" terms or concepts?

- Technology studies responds to a national need.
- Technology studies is equal to the other basics (Big Four?) such as social studies, mathematics, science, and English.
- Technology studies articulates to higher education programs in business, engineering, architecture, design, environmental studies, biotechnology, computer science, and technology in the same way, for example, that social studies articulates with higher education disciplines and majors as political science, sociology, psychology, government, and foreign affairs.
- Technology studies helps meet the United States' need for engineers and scientists and:
  - ◆ reduces need to import talent;
  - ◆ helps the nation to maintain its high rate of productivity in the global competitive market; and
  - ◆ plays a critical role in ensuring that all citizens understand the effects upon them and society of technology and technological change.

Members of the technology profession, particularly those responsible for delivering the program in the lower schools, are inheritors of a good doctrine of which they should be justly proud. With fellow technology professionals from other venues, and hopefully with the aid of the preceding ideas and suggestions, they will gain proper acceptance of their programs. And when that occurs, the citizens and the nation will benefit greatly and the school day will be much enriched for all.

## Supervisor's Perceptions of the Work Attitudes of Two Groups of Employees

Paul E. Brauchle and Md. Shafiqul Azam

The concept of *work ethic* relates to the desirable work attitudes, values, and habits expected from employees. Good work attitudes are often mentioned as attributes that employers want their employees to have, but these attributes are often hard to find. Even though various programs have attempted to address the problem, employers still complain that they are unable to find a dependable workforce (Hill & Petty, 1995). Studies conducted by Custer and Claiborne (1992, 1995) found that both vocational educators and employers gave more emphasis to employability skills than technical skills and basic skills. Employability skills or positive affective work attitudes are not job specific, but are skills that cut horizontally across all industries and vertically across all jobs from entry level to chief executive officer (Sherer & Eadie, 1987).

In the last three decades, attempts were made to identify affective work competencies and construct instruments to measure ethic/work attitudes (Kazanas, 1978; Beech, Kazanas, Sapco, Sisson, and List, 1978; Petty, Kazanas, and Eastman, 1981; Brauchle, Petty, & Morgan, 1983). Working on this line of research, Petty (as cited in Hill & Petty, 1995) identified 50 work ethic descriptors that in the end became the Occupational Work Ethic Inventory (OWEI).

Using a precursor to the OWEI, Brauchle (1979) studied the relationship between trainee and supervisor perceptions of trainee work attitudes. The results of this study suggested that self-perceptions of trainees' work attitudes did not match the perceptions of their supervisors. Using the OWEI, Minton (1997) found a significant difference between employers' expectations of work ethic and the self-perceived work ethic of secondary school students. In a recent study, Azam (2002) found significant differences between employees' self-perceived work attitudes and their work attitudes as rated by their supervisors. In the same study, significant differences in work attitudes were obtained between information and noninformation employees. However, there appears to be little or no research that focuses specifically on the differences between supervisors' perceptions of work attitudes of *information* and *noninformation* employees.

Information employees perform in jobs that are characterized by (a) comprehensive, open-ended tasks requiring high responsibility and critical thinking; (b) tasks that need little supervision and require active individual initiative; (c) tasks that require creative solutions to non-routine situations; deviations are handled by the lowest level of specialist; (d) continued improvement of performance is as important as completing tasks; and (e) integrated work processes; increased ownership of product and process by the individual (Law, Knuth, & Bergman, 1992).

Noninformation employees perform in jobs characterized by (a) narrowly defined tasks that require minor responsibility; (b) heavy supervision and passive order taking; (c) specific response to a limited number of possible problems with deviations from the norm handled by specialists; (d) task completion is more important than continued improvement of performance; and (e) specific tasks are independent of the purpose in the organization's overall operation (Law et al., 1992).

## Research Design and Method

The purpose of this study was to investigate whether the type of job (i.e., information job versus noninformation job) had an effect on employee work attitudes as rated by their supervisors. In this study, the OWEI, a self-reporting type instrument, was used to record supervisors' responses on the work attitudes of information and noninformation employees. The OWEI is a 50-item instrument developed for measuring affective work attitudes using a 1 to 7 Likert-type scale. It has been found to be a highly reliable instrument that yielded Cronbach's coefficient alpha greater than 0.90 for various populations. In this study, 304 supervisor responses on information employee work attitudes and 277 supervisor responses on noninformation employee work attitudes were used. The number of responses was adequate to conduct a two-group MANOVA according to a prior power analysis (Azam, 2002).

Five test plans were worked out to compare supervisors' perceptions of information and noninformation employee work attitudes. The

MANOVA tested differences using the 50-item OWEI across the four factors (*Ambition, Dependability, Self-Control, and Teamwork*). Perceptions of work attitudes between information and noninformation employees were compared when their work attitudes were rated by their supervisors. The factor scores used were based on the above factors and were obtained by factor analyzing the combined responses of information and noninformation employees and their supervisors on the OWEI (Brauchle & Azam, in press). The test plans were designed with different combinations of dependent variables, the presence or absence of univariate outliers, and using transformed or untransformed scores.

The Kolmogorov-Smirnov test with Lillefore's correction was used to test for normality in the distributions. Because effect sizes given by SPSS output on the MANOVAs do not represent multivariate effect sizes, multivariate effect sizes (Mahalanobis Distance) were calculated based on the procedure given by Stevens (2002). Stevens suggested 0.25 as a small, 0.5 as a medium, and greater than 1 as a large effect size. The MANOVA results included commonly used test statistics (i.e., Pillai's trace, Hotelling's trace, Wilk's lambda, and Roy's largest root).

### Results

Statistically significant differences were obtained between supervisors' perceptions of information employee and noninformation employee work attitudes in all of the five test plans. Two of the obtained effect sizes (Test Plans 2 & 3) correspond with Stevens' (2002) criteria for small effects. Other effect sizes met the criteria for large effects. The power obtained in each of the five tests was 1.0. The MANOVA results for each test plan yielded the same significance level for each of the four test statistics. In terms of descriptive statistics, the results also show that for 45 of the 50 OWEI items, the means of supervisors' ratings of information employees were higher than those for noninformation employees. In other words, the supervisors rated information employees higher on desirable work attitudes than noninformation employees.

### Discussion

This study revealed that supervisors perceive differences in work attitudes between

information and noninformation employees and that the supervisors rate information employees higher than noninformation employees on 45 out of 50 OWEI items. This result supports earlier findings by Azam (2002), who obtained differences in self-perceptions of work attitudes between information and noninformation employees. In that study, information employees rated themselves higher on 26 out of 50 OWEI items. Noninformation employees rated themselves higher on 23 OWEI items. For one item, there was a tie between information and noninformation employees and there may be various reasons for this.

One explanation may be that information employees inherently possess better work attitudes than noninformation employees. The results of this study and the previous study by Azam (2002) imply that this may be the answer because not only do information employees think they have better work attitudes than noninformation employees, but their supervisors agree.

Rater bias might also be a reason for higher work attitude scores of information employees. In a sense, supervisors and information employees can be treated as members of the same group. A basic characteristic of information employees is that they need little supervision. In other words, to some extent, they need to have the qualities of a supervisor, with such employee characteristics as high responsibility, critical thinking, and active individual initiative. In addition, supervisors may be more likely to be promoted from the information employee ranks than from the noninformation employee group. Thus, supervisors and information employees are more likely to be similar than supervisors and noninformation employees. Several studies (Duck, 1973; Huston, 1974; Kelley, 1979; Werner & Parmelee, 1979) reported positively biased performance ratings of subordinates by their supervisors when there were similarities between supervisors and subordinates (similarity of opinions, attitudes, and values; compatibility of roles; pastimes; motivation and other personality attributes; reciprocity of liking; socioeconomic status and biosocial attributes such as age, sex, ethnicity, and level of education). This similarity factor might be a reason for supervisors' higher rating of information employees on work attitude attributes.

It is possible that the lower supervisor ratings of noninformation employees on work attitude attributes are related to the nature of work that the noninformation employees perform. Narrowly defined jobs and limited responsibility provide little opportunity to display good work habits and attitudes that may draw attention from a supervisor. In other words, the job environment for noninformation employees probably does not provide much opportunity to display good work habits and attitudes, other than refraining from behavior that slows down production or affects quality.

Another reason for the relatively poor showing of noninformation employees may be that they work at jobs where exceptions (poor quality, product defects, accidents, time off task, inattention, etc.) are more readily visible and quicker to affect production than errors made by information employees. Because many supervisors still use the principle of exception (Certo, 2000), deviations from the norm seem more prominent to them in noninformation employees than information employees. Additionally, noninformation jobs are more likely to have a supervisor close at hand and may, therefore, notice any exception to desired performance. However, further investigation is needed to identify precisely why there is a difference in work attitudes between information and noninformation employees and why information employees are more likely to exhibit better work attitudes

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than noninformation employees.

Whatever the reason, it is clear that a new kind of employee, the information employee, is becoming more prominent in the workforce, and these employees are perceived differently by their supervisors than the more traditional noninformation employees. Because information and noninformation employees are different in so many ways, supervisors of the future may need a new skill set to properly manage both groups of workers. Research is needed to shed light on the reasons that supervisors perceive these two groups of workers differently, to determine whether these perceptions are based on real differences between the two types of workers or just the orientation of the supervisors, and to ascertain which skill sets are best used by supervisors in dealing with both groups of employees.

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## Portfolios: Conceptual Foundations and Functional Implications

Andreas Luescher and John W. Sinn

As is true at many institutions of higher learning, Bowling Green State University (BGSU) in Ohio is in the process of testing, rating, and adapting the portfolio as an addition to its arsenal of assessment tools with application to classroom, administrative, and professional development domains. The College of Technology at BGSU, in particular, has been exploring the nuts and bolts of portfolios with a focus on the transition of technical students to technical professionals.

Our thesis is that portfolios represent a heuristic methodology that yields a sensitive and adaptable indicator for the assessment of student development. The importance of marketing to academia cannot be ignored; even though many academics protest the corrupting influence of money on the purity of academic research, mar-

keting is irrefutably as much a part of the academy as it is the world of commerce (Kliment, 1998). Because of the portfolio's dual existence as a marketing tool and as a matrix for intellectual exploration and reflection, it is increasingly relevant to the marketing aspect of academia.

In this article we address several important areas that combine to illuminate the portfolio as performance, index, and design. We provide an in-depth look at the conceptual foundation and selected functional implications of portfolios. Accordingly, the foundations laid here may serve as a basis for further development and application to a comprehensive application of the portfolio methodology.

### Background and Definition

The portfolio simultaneously adheres to

and defies the notion of an assessment tool. As a heuristic methodology, the portfolio offers opportunities for assessment of the work of oneself and of others in a context of professional and intellectual growth. This quality of heuristic, or self-instruction, is at the core of the portfolio's uncomfortable residence in the world of assessment. It transcends disciplinary boundaries and developmental hierarchies in application, but it is a notoriously hard format to pin down or quantify. The strength and the weakness of the portfolio format is that it foregrounds qualities of experience. Portfolio methodology showcases mechanical and imaginative skills. By nature this methodology also leads to inquisitiveness about possibilities and tangents; it also brings up questions about chronology and authenticity. Instead of pursuing the psychological or philosophical implications of the portfolio as a performance medium, we concentrate on the portfolio as an ideology that places the value of individual work efforts within the greater context of learning to think, which benefits artists and technicians, undergraduates, and mid-career professionals alike (Seguin, 1991).

The portfolio model stands in opposition to a value system that favors the individual measured against his peers. This is the world of standardized or quantitative experience. Instead, the portfolio represents a value system which emphasizes that which is immeasurable: the qualities of experience. This distinction tempers all implications of the portfolio as an assessment tool. Goffman's *The Presentation of Self in Everyday Life*, originally published in 1959, explores the details of individual identity, group relations, the impact of environment, and the movement and interactive meaning of information. His perspective, though limited in scope, provides significant insight into the nature of social interaction and the psychology of the individual. The actor performs interactively in order to present a compelling front. This process, known as "dramatic realization," is predicated upon the activities of "impression management," the control (or lack of control) and communication of information through the performance.

Equally controversial is the portfolio's dual existence as a matrix for intellectual exploration and reflection and as a marketing tool; portfolios will increasingly be used, particularly due to rele-

vant and purposeful direction, in an academic, professional, or personal career. As previously stated, marketing is as much a necessity in the academy as it is in the market. To the extent that portfolio assembly is concerned with the design and presentation of information, or "impression management," it can be seen as a corrupting factor, an insertion, or gloss obstructing the real or "authentic" evidence of knowledge possession (Goffman, 1959/1990). The question "Evidence of what?" comes from those who challenge the indices generated by standardized testing. What exactly is being measured: performance or possession? Does portfolio methodology tip the scales of assessment toward the form of information (interface, packaging, etc.) to the exclusion of its content? How adequately do portfolios straddle the blur between the qualitative and the interpretive?

Broadly represented in this article are several different types of portfolios including (a) a student portfolio: a show of accomplishments for a class; (b) a project portfolio: a documentary of project or independent study; (c) a personal portfolio: a scrapbook or collection of one's interests; (d) a professional portfolio: an organized collection of complex, performance-based evidence that indicates one's growth, goals, and current knowledge and skills needed to be competent in a role or area of expertise; and (e) a teaching portfolio: a selection of artifacts and reflective entries representing a teacher's professional experiences, teaching competencies, and growth over a period of time (Campbell & Brummett, 2002; Syre & Pesa, 2001).

Accordingly, our study supplies the following details as evidence that portfolios are a highly flexible instructional and assessment tool, adaptable to diverse curricula and administrative contexts.

### Student Portfolio: Classroom and Administrative Uses

Questions surrounding portfolio implementation in the classroom since its introduction to the normative routine in the 1980s are those of process and strategy. Ideally, the portfolio crosses diverse curricular settings. Students are challenged to take charge of their personal collection of work, reflect on what makes some work better, and use this information to make improvements in future work. The portfolio is a way for teachers to structure student involvement in developing and understanding criteria

for good efforts, in coming to see the criteria as their own, and in applying the criteria to their own and other students' work (Campbell et al., 2000).

A decade of portfolio-specific research has shown that students benefit from an awareness of the processes and strategies involved in writing, solving a problem, researching a topic, analyzing information, or describing their own observations (Gardner, 1993). In building a portfolio of selected pieces and explaining the basis for their choices, students generate criteria for good work, with teacher and peer input.

Central to the importance of portfolio methodology is the idea of sensuality. It is the sensual appeal to the process of storing and retrieving information that distinguishes the portfolio as a didactic method. The portfolio is nothing so much as a mirror of the individual psyche. This leads to the central conflict surrounding the portfolio as an assessment methodology. Who "owns" the criteria? Who quantifies the assessment? Is it the individual performer or the audience?

Critics point to portfolio methodology as a symptom of *anomie* or loss of standards. Proponents of portfolio methodology point to a compromise between individual and societal requirements. In practical terms, "packaging" the component of portfolio, which asserts itself in ways that are uncomfortable to the notion of academic purity, questions whether the design of information supercedes and/or corrupts the authenticity of the information represented.

Our thesis is that the design and presentation of information—in other words, the emphasis on form—does not diminish the role of substance, skill, emotional content, worldview, or appropriateness. The principles of form are universal and immutable. They include compression, grasp of the essential, balance, and ideality. Form provides the spark without which content languishes. The portfolio as a methodology features the criteria of quality performance. The hope is that by engaging students in performance and critique they can apply these criteria to their own work and monitor their own progress, chronicling work and opening new channels for substantive communication.

Perhaps the key to the importance of portfolio methodology is the kinetic and haptic

dimensions the process adds to understanding and self-awareness. Portfolios provide a vehicle for instruction focused on the processes and strategies underlying effective performance. They allow accomplishments and growth to be identified and assessed in a context well beyond traditional classrooms. In essence, portfolios are defined as selected performance. Beyond that, definitions vary widely in relation to content, purpose, and structural elements (Campbell et al., 2000).

Both inside and outside of schools, observers are uneasy about what role portfolios, commercial tests, and other assessment tools should play in administrative activities. Questions have centered on the technical adequacy of portfolios for administrative decision making and reporting. Are they comprehensive enough? Are they reliable enough? Are assessments generalizable within a specific curriculum area? Inasmuch as portfolios allow identification of areas of weakness, academic institutions can employ portfolios as a means of assessing their success at meeting institutional goals. Indeed, student portfolios are being used for institutional accountability reporting, program evaluation, and a variety of administrative decisions affecting the future of individual students. Are portfolio systems sufficiently informative and technically strong enough for these added functions? Also, what is involved in making them adequate to the structural and content requirements of accountability, evaluation, and student-level administrative decisions?

Again, the crucial questions center on "authenticity." Are portfolios merely evidence revamped to satisfy technical requirements? Or can they still play a constructive role in teaching for understanding? Can portfolios answer to all calls and still motivate students to be active learners? Can the portfolio format be standardized without losing its classroom application, which foregrounds the expansion of the individual students' setting of self vis-à-vis society?

The shift to administrative evaluation and to the education system, in other words, away from individual students, teachers, and classrooms, introduces a broader and less well-defined audience. While administrative uses of the portfolio require increasing standardization (and at least a partial shift in ownership), a student's sense of ownership of his or her portfolio is linked with interest, motivation, and actual

engagement. Some compromise between centralized structure and local, classroom-level discretion may work just as well (Costantino & De Lorenzo, 2002).

Should there be unique courses to cover the redundancy at the heart of portfolio/self-reflective activities, and should this system exposure and control be integrated institutionally? The answer is yes. Furthermore, while a single course can—and should—be dedicated to the process of developing a portfolio, it is essential that subsequent courses reinforce the importance of adding to and refining one's portfolio materials. The portfolio model is a testament to the value of redundancy.

### The Case for Portfolios, Added Definition, and Functional Approaches

The portfolio answers the requirements of an increasingly visual world as a visual document, but resumes and curriculum vitae have been the standard experimental summary in business and academia since the 1960s. Resumes and curriculum vitae were created at a time when informal networking and insider connections were suddenly inadequate as a delivery system for the numbers of new positions and applicants created by the postwar economic boom. Developed to efficiently compress pertinent information in a very particular way, resumes and curriculum vitae remain an essential career tool (Berryman, 1991, 1994; Porter, 2000). But the portfolio can be much more than a resume or collection of work.

Like professionals in any discipline, records of our activities accumulate in brief cases, file drawers, and Zip drives. It is from these various forms of documentation that we can extract a focused and coherent representation of our history. When applying for admission to graduate school, for tenure at a university, or when looking for a new position or freelance work, an applicant generally selects the finest examples to make the strongest case for his or her abilities and experience. Composed of good samples of past work presented in a clear, unambiguous, and accessible form, that document was a portfolio (Linton, 1996). The use of a portfolio goes beyond the mere collection of information as a cosmetic arrangement of loose pieces of work in a folder. The assembly of a portfolio is not merely about "looking good" (Scher, 1992); it is an essential documentary tool for anyone who does creative

work in any field.

Building the portfolio falls into *source* and *mini* or *disposable* approaches. Source portfolios contain original (non-reproduced) work whose security should be protected; pieces might be selected from source portfolios to take to interviews. By contrast, mini or disposable portfolios made up of reproductions of original work represent the difference between *ephemera* and *accretion*. The mini or disposable portfolio is a mass-produced version. An abbreviated introduction to one's work, the mini or disposable portfolio is generally made up of examples that are easy and affordable to reproduce.

In the same way that the student portfolios are adapted from older forms of presentation, professional portfolios are similar to the traditional resume and curriculum vitae. As job titles continue to become obsolete and as hiring practices shift from permanent and full-time workers to independent contractors, temps, consultants, and freelancers, traditional formats may offer an insufficient summary of one's experience (Kimeldorf, 1997). A portfolio offers hard evidence of problem solving by graphically revealing both the direction and depth of one's experience. It answers the "show-me" demands of employers and is, therefore, an important technique of self-presentation. Unlike the resume or the curriculum vitae, the portfolio emphasizes the qualities of experience rather than the objects or names of experience. The portfolio goes beyond merely talking about a topic or entry to actually demonstrating the issue or item under discussion.

Creative professionals are likely to assemble several portfolios in the span of a career. A personal portfolio is required to enter graduate programs in many disciplines while a project portfolio can measure the quality and dimension of one's undergraduate study. As a career develops, a professional portfolio includes updated samples and projects in progress. A personal portfolio functions purely as a method of self-reflection, often evolving into a source of propulsion toward new endeavors that, given time, eventually evolve or overlap in professional activities.

### Making the Portfolio Happen: Student-Based Concerns

Familiarizing students with virtual presenta-

tion via electronic portfolios will help them to better understand the phenomenon of synchronic practice over a distance as well as communication and display protocols unique to remote collaborations. But how should this be done? Should there be unique courses to cover such activities, or should the act of developing a portfolio be integrated into all that is done for professional preparation? The answer is simple—both. Although a course can, and should, be dedicated to the process of developing a portfolio, it is essential that subsequent courses reinforce the importance of adding to and refining one's portfolio materials.

Students must transpose original portfolio items into electronic files. Like the traditional portfolio, the electronic portfolio is a performance. Both types of portfolio establish a narrative that is concerned with the linear piecing together of continuous or disconnected images and events. In addition, both types require decisions about how much space and emphasis to give to each successive visual event in the presentation. But the electronic portfolio is a performance with different dimensions, quite literally, from the traditional portfolio. It must be carefully managed if the "message" of the medium (i.e., the linkages) is to enhance rather than diminish the original material, primarily due to issues raised earlier.

Because of the freer and more varied technologies of image manipulation that are available, designing electronic portfolios differs from designing the traditional portfolio. The addition of movement and sound can enhance the presentation, but it also means that more must be managed and understood in construction. Questions to be addressed instructionally include awareness of solutions for structuring contents and navigation in a screen and time-based medium. Development of guidelines and criteria for the efficient streamlining of the process, including assessing work electronically, will be required (Cambridge, Kahn, Tompkins, & Yancey, 2001).

Development of electronic or multimedia portfolio instruction is imperative for teaching and for encouraging portfolio use among students. The complexities and sophistication of electronic programs make them difficult for one to utilize without some type of intentional instruction. Portfolio and presentation instruction is meant to provide a bridge between the student and professional worlds by offering stu-

dents the chance to see their work and themselves in the broader context of the marketplace. The goal is to link technical education and careers by working in the context of the way things are produced in the business world via practical skills (specifically, knowledge of strategies for collection, organization, design, and evaluation of an evolutionary document—the professional portfolio) for accomplishing personal marketing and presentation tasks (Marquand, 1985).

### Electronic Opportunities and Challenges

If portfolio assembly is merely a matter of student transposition of original material to electronic files, the electronic portfolio is—like the traditional portfolio—a performance. Both portfolios establish a narrative that is concerned with the linear piecing together of continuous or disconnected images and events. Both portfolios also require decisions about how much space and emphasis to give to each successive visual event in the presentation. Similar to a paper portfolio, the electronic portfolio offers options and encourages evaluators to spend more time in the portfolio. Like paper portfolios, the electronic portfolio offers options for both linear and nonlinear navigation. It takes the form of a guided tour, helping to point evaluators toward particularly relevant pieces, just as it takes the form of random access, inviting intuitive investigation. The portfolio method can be navigated either way, allowing evaluators to decide which pathway (linear or nonlinear) is most appropriate at the time they review the portfolio. A consistent navigational scheme allows evaluators to find any particular piece with a minimum of effort and searching (Sanders, 2000).

While concerns about electronically supported portfolio practices exceeding physical boundaries are common, virtual conference and collaboration is more convenient and less expensive. Telegraphy follows on the heels of telephony. Familiarizing students with virtual presentation via electronic portfolios, especially in the realm of technology education, clearly provides an essential exercise in synchronic practice over a distance, particularly communication and display protocols unique to remote collaborations.

A central question remains: What is the bottom line applicability of the portfolio

method? Is it simply a demonstration of software knowledge? In some ways, it is. Development and refinement of digital media coupled with the explosion of Internet usage during the last five years has expanded a world culture increasingly mediated by electronic technology for visual presentation. An effective electronic presentation can demonstrate conceptual skills not evident in a traditional physical-static format. It involves skills in scripting, image sequence, and viewer navigation, and as such, it showcases one's ability to organize according to hierarchies, matrices, series, overlays, spatial issues, and parallel texts. Like theatrical, cinematic, or musical events, the electronic portfolio must be timed and paced to address the flow of information in a multidimensional, multisensual environment.

The drawbacks of electronic portfolios include the fact that they are implicitly measured against the mass media. Electronic portfolios must fit the playback hardware of the user or reader assessing the information. While technical advances may eventually overcome incompatibility issues, a major issue inherent in the electronic portfolio is the absence of the actual human presence. The spontaneous response and the physical interaction are removed in the traditional sense when moved from a physical document or presentation to an electronic portfolio. Questions about electronic portfolio security are also of concern, as is the ability to know who actually completed the work being viewed electronically. Ironically, portability (i.e., system compatibility) between sender and receiver is a source of awkward and clumsy communication transmission.

### Functional Implications

The model in Figure 1 is a conceptual layout of a portfolio system-process for undergraduate studies in the professional curriculum. This model shows portfolio checkpoints, or stepped phases, for assuring that students are successful from start to finish. Checkpoints also provide potential involvement by students in student organizations and other broad-based university-wide experiences.

The checkpoints include several key steps, phasing the portfolio assessment over the entire degree process:

- Checkpoint I: Initial phase—collecting and organizing all work.
  1. Fundamental skills

2. Technical skills
3. Practical skills
4. Ethical skills

The second checkpoint engages students in determining when and how to integrate important activities such as co-ops into their experience.

- Checkpoint II: Portfolio assessment—planning and evaluation.
  1. Find strength and weakness
  2. Evaluate university/college/departmental/program performance
  3. Develop goals for future growth
  4. Review accreditation standards (i.e., NAIT)

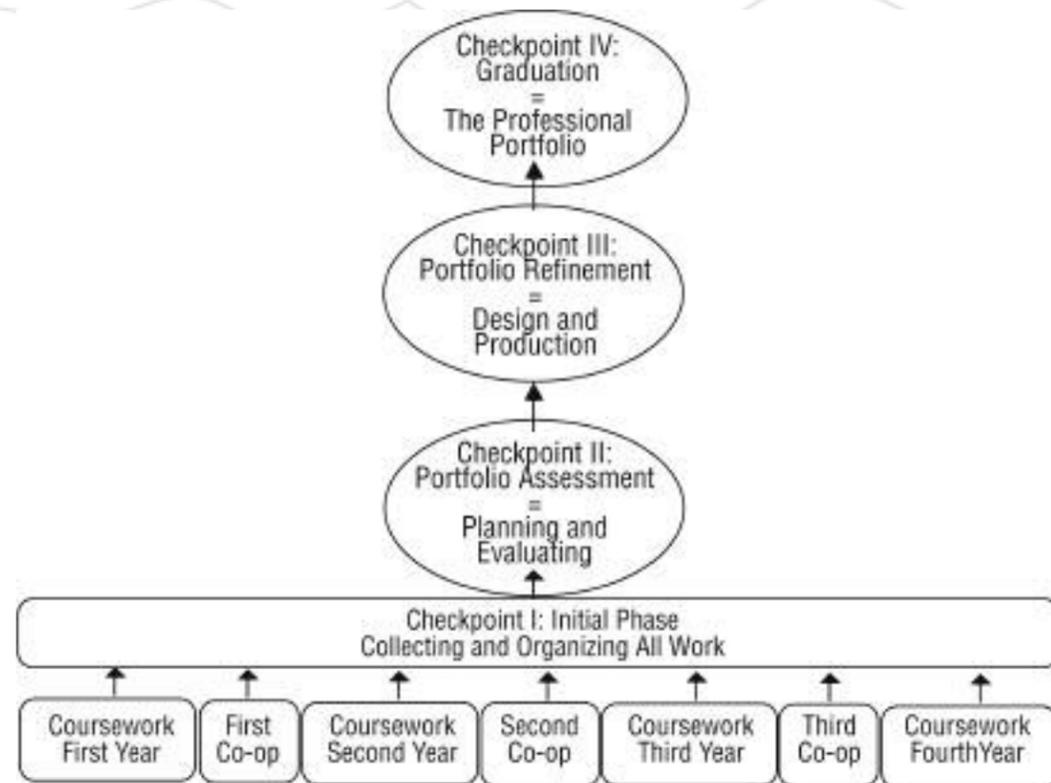
The third checkpoint broadens the student perspective to include a phase with participation with professional senior members through conferences and advisory committees as part of the broader assessment system based on refinement, further design, and actual production.

- Checkpoint III: Portfolio refinement—design and production.
  1. Employ written and graphic modes of communication
  2. Apply a concept of self-reflection
  3. Make sound judgment concerning career
  4. Communicate a vision

The final checkpoint is the phase of assessment, which requires actual presentation, electronically and physically, of the total portfolio product: graduation. It is suggested that graduation occur only after successful completion of the portfolio.

- Checkpoint IV: Graduation—presentation of the professional portfolio.
  1. Evidence of university/college/departmental/program outcomes
  2. Evidence of leadership in the field
  3. Evidence of professional experience
  4. Evidence of preparation for the job market

At BGSU, several portfolio initiatives to integrate portfolio methodology are underway including the offering of a professional portfolio course, the establishment of an Electronic Portfolio Information Center at the university level (<http://folios.bgsu.edu/epic>), program-specific and online portfolios, and teacher training in portfolio methodology.



**Figure 1. Conceptual layout of a portfolio system-process for undergraduate students.**

In practical terms, one example is a professional portfolio course currently offered at BGSU. *Professional Portfolio*, initiated in 2000, lends credibility to proponents of core courses in professional curricula. This course is designed around the premise of a coalescence of experiences and coursework. Portfolios developed by students working independently and in teams reflect the interdisciplinary assessment function in robust and obvious ways related to the curriculum and professional preparation.

Not only can a portfolio course be used as an introductory vehicle for structuring various experiences, but various courses in the curriculum can also be used to integrate and build the portfolio along the way. In other words, the portfolio as a methodology is a means by which institutions or individual instructors measure their success at attaining the goals set forth for their students in the classroom. A key component of course design in this case is the identification of core values as reflected in learning outcomes. Five learning outcomes constitute broad BGSU core values: analysis, integration, communication, interaction, and disciplinary

knowledge. Each graduate will also have multiple professional imprints unique to the College of Technology that include technological problem solving, pragmatic field insight, application capability in research and development, cultural global perspective, and skill in the communication of concepts and ideas.

At the university level, portfolio techniques such as assessment, organizing information, and developmental progress are being tested for traditional freshman transition courses as part of the matriculation process. Along with other basic study skills, students learn how to evaluate what they are learning and how they are learning. The university learning outcomes offer the basis for transforming educational practices from teaching-centered coursework to active learning.

Students are taught to identify for themselves examples of various learning outcomes (e.g., critical thinking, writing skills, presentation skills, leadership, and making connections). In addition to examining the process by which they are learning, students also learn to identify examples of their own “best work.” Samples

that demonstrate both their abilities in the learning process and their abilities in their area of study are added to their portfolio. The process will help students to develop and judge their progress toward their own educational and career goals.

Examples from one such professional curriculum, Quality Systems, can be reviewed at [www.bgsu.edu/colleges/technology/qs](http://www.bgsu.edu/colleges/technology/qs). This site is designed to demonstrate and explore how a faculty Web site portfolio can be integrated into the broader learning community. At the site, go to *Teaching* and then prompt *Student Work Examples* to see various portfolios in process. Prompting *Example Courseware* will also provide insights into one interpretation of how to help guide the portfolio development process electronically.

The five learning outcomes and the college’s “imprints” are all reinforced in various ways in the professional curriculum, upheld as adding important value to the total undergraduate experience. The foundational learning outcomes are intentionally reflected as core values in the professional curriculum, noted specifically as elements sought after and reflected via core knowledge. Assessing these outcomes through the portfolio is designed to assure that the learner makes steady progress. Outcomes are assessed through a combination of courses, professional experiences and certification, and incremental preparation of a portfolio which ties it all together.

Teaching portfolios are performance-based assessment tools that promote quality teaching at the college level. When used effectively, teaching portfolios can enhance focus and refinement of classroom teaching. As an example, teaching portfolios could be used to assess the outcome of team-based project planning, analysis, and execution. This outcome is assessed through completion and review of classroom performance requirements and core courses. The end result is a continuously built, cumulative portfolio to reflect projects planned, designed, and executed by the learner, either in a team or individual atmosphere. Periodic reviews of the evolving portfolio in core courses and through a final presentation to faculty and professionals in the field will occur via ongoing electronic postings and traditional presentations,

documenting learner growth and professional preparation in various courses and experiences.

Monitoring participation in student organizations assesses the outcome of professional and leadership skills certified. Student membership is suggested, along with successful completion of various professional certification exams. Additional professional portfolio items could include presentation materials or experiences from a professional conference.

Although not new, portfolios have recently enjoyed revitalization due to cultural changes identified in this article. This may be true not only for students in technical areas, but also for students in any discipline. Portfolios, particularly those created electronically, will provide many challenges and opportunities to academia.

Portfolios are equally important as students prepare for various professions, allowing all growth and accomplishments to be identified and assessed in a context well beyond traditional classrooms. Portfolios allow identification of areas of weakness in academic curricula as well as ways for faculty to assess their own effectiveness in the classroom. Institutions are also beginning to use portfolios as a means of assessing their success at meeting institutional goals.

We have just begun to tap the surface of the potential uses of portfolios. The future may see a completely new system of assessment in institutions of higher learning. Students would no longer earn grades in individual courses; rather, a portfolio could be begun as a freshman and modified and refined over time. Upon achievement of a certain level of excellence, the portfolio would be approved and a degree awarded.

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## Distance Learning: A Comparison of Classroom Students With Off-Campus Television Students

William L. Sharp and Edward P. Cox

The study summarized in this article was undertaken to increase the level of understanding of some of the issues associated with distance learning in higher education. We sought to do that by gathering and comparing direct feedback from both on-campus and off-campus students regarding discussion, attendance, and student assessment procedures. The students participating in the study were taking classes in the Department of Educational Leadership at Ball State University (BSU). The results will be of interest to those already involved in or considering a distance education initiative.

### Background

Today's universities no longer expect their undergraduates to be 17 to 21 years old and their graduate students to be a few years older. The student population has changed over the years with many older adults attending universities and urging the universities to provide instruction in ways that would have been unheard of a few years ago. "Working adults want education delivered direct to them, at home or the workplace.... Preparation may be weaker than among conventional students; motivation may be stronger" (Jones &

Pritchard, 1999, p. 56). These new methods of delivery include television and the Internet, both of which allow students to access coursework miles from the traditional campus classroom. Thorpe (2000) reported that one course offered over the Internet recruited "over 9,000 students in February and another 4,000 in May" (p. 11). While this may not be typical of the student enrollment in most distance learning courses, it does indicate that instruction will have to change and that assignments will need to be more tailored to a population that is not on campus. The population of the distance learning format means that college instructors will increasingly encounter classes that are much larger than the traditional graduate level class. Not all courses are ideal for distance learning, and decisions regarding which courses are selected for distance education need to be carefully considered. It is one thing to offer a course via distance education because this method of delivery will not harm the content and may, in fact, enhance it. It is quite another to schedule a course for distance education simply because there will be a large market for that particular course. As Lamb and Smith (2000) pointed out, "The distance education environment tends to exaggerate both the positive and the negative aspects of all the elements of instruction" (p. 13). Kelly (1990) mentioned that instructors must develop new skills for distance education teaching in the areas of timing, teaching methods, feedback from students at remote sites, and the evaluation of students. Student assessment, in particular, provides many challenges to those involved in distance education.

Because of the differences between traditional instruction and distance education, it is important, whenever possible, to determine the effectiveness of the new methods of delivery and periodically compare them to traditional campus classroom instruction. Swan and Jackman (2000) discussed Souder's 1993 comparison of distance learners with traditional learners, stating that the distance learning students "performed better than the host-site learners in several areas or fields of study, including exams and homework assignments" (p. 59). Citing the limited number of studies comparing different methods of instruction, Swan and Jackson looked at remote-site and home-site students at the secondary school level. They

found no significant differences in student achievement between the two sites when comparing grade point averages.

In keeping with this need to compare students in traditional classrooms and students at remote-site locations, we decided to compare the perceptions of our students in two different traditional classroom courses with students who took the same courses via television.

### Methodology

As professors in the Department of Educational Leadership at BSU in Muncie, Indiana, we surveyed graduate students in our School Finance and School Principalship classes. Of these students, 12 in the finance class were in a studio classroom, with 89 taking the course on television at 42 off-campus sites around the state of Indiana. In the principalship course, 25 students were in the studio and 60 were at 22 remote television sites. The purpose of the survey was to see if there were any different points of view regarding the questioning format, attendance, and assessment procedures between the studio groups and the groups at the remote sites. We also wanted to collect data regarding any technological problems and about the students themselves and their backgrounds.

These courses utilized the following format: Finance class—one class for four hours, twice a week, for five weeks, with all students (on-campus and off-campus) taught at the same time; Principalship class—four hours, twice a week, for five weeks for one class and four hours for 10 consecutive weekdays for the other class. All of the on-campus and off-campus students in the principalship class were taught at the same time for each of the two classes.

Students at BSU complete course evaluations at the end of each course. The survey for this research study was added to that evaluation form so that all students would complete the survey. In accordance with the policy on evaluations, the studio groups were given the forms by another student, with the professor outside the classroom, and the evaluation/survey forms were returned to the department office by the student, where the forms were scored by a secretary. The results were not given to us until after final grades were submitted. Proctors at the remote sites distributed surveys to the students to complete and mailed them back to the office for scoring. Thus, every student in atten-

**Table 1. Prior Experience With Television Classes**

No. of Previous Classes	Studio Students	Off-Campus Students
0	30.6%	42.6%
1	22.2%	23.3%
2	19.4%	14.7%
3	16.7%	6.2%
4 or more	11.1%	13.2%

dance completed a survey.

The results of the surveys for this study were then entered into a computer at BSU, and SPSS 10.0.2 was used to obtain a frequency analysis of the data from the surveys.

**Results and Discussion**

One thing that we wanted to learn was the extent to which these students had experience with television classes. For example, the attitude of the on-campus students towards the off-campus arrangements (taking time for attendance, discussing technological problems, etc.) could be affected if they had also utilized these off-campus classes in the past. We also wanted to know the total amount of experience that the students had had with television classes to see how popular this format was for these students (see Table 1).

The majority of students in both groups had prior experience with television classes, and some students had extensive experience. The students in the studio classroom had more experience than those taking the courses at the off-campus television sites. This may help explain why the majority of on-campus students were generally understanding regarding interruptions from off-campus sites.

The technology enabled students at the remote sites to push a button to “dial in” to talk to the professor during class. When someone “dialed in,” a beep would sound in the studio classroom indicating that someone was calling. In discussing live television classes with other instructors, we were told that one common

problem was that the students would call in without warning (unlike students raising their hands in class) and interrupt the flow of the class for all the other students and the instructor. Since we wanted to avoid this problem and still give students the opportunity to ask appropriate questions during class, both of us told students that they could only call in to ask questions during designated question and answer times. In the finance class, the on-campus students were asked to follow the same rule (though some forgot from time to time), whereas the professor for the principalship class allowed on-campus students to ask questions without waiting for a prompt from him. Since this “waiting for permission to ask questions” was so different from the usual graduate classroom routine, we wondered how the students would accept this new procedure. In our classes, the students cooperated and were very good about not calling into the studio until we asked for questions or called on students to call in to answer questions that we had posed. In the survey, we asked the students for their opinion on this “no call-in” rule. The results indicated that 82.1% of the studio students said that this rule was reasonable due to the class size, and 83.5% of the remote site students agreed. This was gratifying to us because we felt that the rule worked very well but were concerned that the students would find it objectionable.

Since these phone calls from the remote sites, when they did occur, would make a buzzing noise followed by a “voice from the sky,” the studio students were asked if they were bothered by these call-ins. Findings indicated

that 66.7% of the campus students said that it was never true that it bothered them, and 30.6% said that it was sometimes true. So, even though calls were restricted, some of the studio class students (30.6%) were bothered by calls from the off-campus sites.

As in most classes, attendance was taken. However, the size of the classes meant that attendance took longer to take. This process was sometimes done early or at break time or during questions and answers. The students were asked whether it was still appropriate to take attendance in these large classes. In the studio class, 76.7% said that attendance should be taken, whereas 56.0% of the remote-site students felt that taking attendance was appropriate. Some off-campus students may have noted the possibility of being absent without being noticed or they may simply have been less patient with the lengthy attendance-taking process.

Another change from the traditional classroom was the way in which students were tested. While some previous television class students had been required to come to campus for mid-terms and final examinations, we felt that this defeated the purpose of having students take the course at various sites throughout the state. As a result, there were two other options: We could use the usual pencil and paper examination and mail them to the remote sites where a proctor would supervise the exams and return them by mail, or we could put the exams on the Internet and students could take them by computer. The first had the advantage of security/supervision but entailed the mailing of exams to the proctors and then back to the campus where the exams had to be graded by hand. The computer method of examination provided an electronic time limit after which the student could no longer answer any questions. Also, the computer exam would immediately be graded electronically so that the instructor and student would have immediate feedback. One of the drawbacks was that there was no supervision of the student who could take the exam at home or at any Internet site during the specified time.

Both methods were used in this study. The students in the School Finance class were sent written examinations for both mid-term and final exams, whereas the students in the School Principalship classes were given computer exams. When the students were asked whether

they preferred the way they were examined or whether they would prefer the alternate method, students in both classes preferred the way they were tested, even though they were tested in different ways. For the studio class taking a paper test (finance class), 100% said that they would prefer a paper test; for the off-campus students taking a paper test, 79.5% said that they liked that method. For the studio classes that took their exams on computer (principalship class), 68.2% said that they would prefer the computer for taking exams; for the off-campus students taking the computer test, 91.9% said that they would prefer that method. This seems to suggest that either way is acceptable to students. Since access to computers was the same for all students and since paper tests could have been used for all students, it seems that students simply preferred what was familiar to them.

Since there is always the possibility of technological problems when broadcasting a class to many students at numerous sites around the state and using computers and the Internet for the courses, we surveyed the students about these problems. Students attending class in the studio were not required to use technology to ask questions or talk with the us before or after class, and they did not lose picture or sound when weather conditions worsened. If any studio students had been adverse to technology, it would not have affected these aspects of their class. For off-campus students, however, the same limitations mentioned could cause problems for them.

Each of us established a Web page where students could obtain course information: the syllabus, handouts, additional Web sites, and their grades on exams (whether or not they took paper or computer exams). Students utilized a code and password to navigate some menus to reach this information. When asked if they “got the page,” 71.4% of the studio students said that they had no trouble in getting it, while 79.8% of the off-campus students responded in the same way. Only 11.4% of the studio and 0.8% of the remote students never tried to locate the Web page. This indicates that while most students tried to locate the Web page, the instructors may have to spend more time in future classes to demonstrate how this is done since over 20% did have trouble locating the Web page (28.6% of studio; 20.2% of off-campus students).

The television system sends out video and

audio signals via satellite to schools or other facilities equipped to receive them. Besides the possibility of mechanical breakdown, stormy weather can also cause problems in the transmission, and these courses were given in the summer when such storms could be anticipated. When asked about problems with the audio and/or video, 58.9% of the off-site students said that the system worked all the time, 32.6% said that it sometimes did not work but was not a problem, and 8.5% said that it did not work a lot of the time and was a problem for them. Students were provided a phone number to call for help when there were serious problems. It was reassuring to know that over 90% felt that they did not have a real problem with the television technology.

As mentioned earlier, students at the remote sites could call in for attendance or questions/answers on a phone system by pushing a button on a special phone at their site. This phone system worked all the time for 65.6% of the students, sometimes did not work but was not a problem for 29.7%, and did not work a lot of the time and was a problem for 4.7% of the students. For example, one student mentioned that there was roof work being done on the school where he was attending class and that the phone system never worked during the course. As noted earlier, students were given a regular phone number to call into the television studio director's office and report problems with their special phones or problems with the television system. The director then notified us during the class and noted whether this was an isolated case or whether there were other sites that were having problems. Although 60.9% of the students did call into the studio to report technical problems, previously mentioned findings indicate that their outages were not considered a problem for most of them (58.9% had no problem; 32.6% did not consider the glitches a problem, as stated earlier).

In the event that the television signal was lost, students could request videotapes of the sessions that they missed. There was no cost for this service if technical problems caused them to miss all or part of a class. These off-campus students were asked if they ever had to order tapes of the presentations because of technical problems. The responses indicated that 10.2% ordered one tape, 1.6% ordered more than one tape, and 88.3% did not have to order any tapes.

So, again, it appears that technical problems, though present at times, were not a major problem for the vast majority of the students, and there were provisions made for those who did have problems.

We wanted to know about the gender of the students and their background. Previous researchers have sometimes stated that females had more problems with technology than males, and we wanted to see if females tended to take the on-campus class or the off-campus class or whether there was any difference in their choices. Also, we wanted to know what percentage of the class was classroom teachers and how many students taking these administrative courses were already school administrators. Finally, since recruitment of students is important to a department's survival, we wanted to know if we had students in our classes who were actually in programs at other universities and took our course out of convenience. So, questions were asked to gather information about the students themselves: gender, whether they had been BSU students in the past, why they took the course, and how they found out about the course. Regarding gender, the studio students were 67.6% female, whereas 45.7% of the off-campus were female. In the studio class, 61.8% of the students were classroom teachers and 29.4% were school administrators. At the remote sites, 68.2% were teachers, with 23.3% administrators. While the statistics on gender do not indicate why the students chose on-campus or off-campus classes, it is worthy to note that females did select the on-campus class more than the off-campus sites. This is an area for further research.

When the students were asked about their degree programs, 89.2% of the studio students stated that they had been admitted to a BSU degree program. Off campus, 70.5% were BSU students, with an additional 21.7% taking the course for certification only and not part of any BSU degree program. As expected, the course was being taken to meet a degree requirement, an administrative certification, or both. When asked about the reason for taking the course, 100% of the studio students and 97.7% of the remote students stated that it was a required course for a degree and/or certification. When asked if they already had a degree from BSU, 80.6% of the studio students had at least one degree from BSU, whereas only 35.2% of the

off-campus students had a degree from BSU. This was important to us because it demonstrated that the television courses attracted more than just BSU students. These students may have been taking the course because it was not available from another Indiana university, or they may have just needed the course for administrative (principal) certification from the state. This expanded student market, made available by distance learning, impacts professional staffing level requirements and provides valuable exposure for the university to potential new students.

Other questions were asked to determine the reasons they chose this particular method of course delivery. The studio students were asked if they would have preferred to have taken the course off campus instead of coming to the studio. Although 30.6% said that this was sometimes true, 69.4% stated that it was never true. The students who took the course off campus did not have to pay student fees (recreation, library use, sports and musical tickets, etc.) and only paid tuition for the three-hour graduate course. Students on campus had to pay the full tuition and fees amount. When we asked the off-campus students the advantage of taking a course on television, 100% said that it was for convenience. No one chose the option stating that it was cheaper than on campus. In fact, 53.9% said that they did not even know that it was cheaper than taking it as a campus class. An important question for the off-campus students was the following: "Considering the advantages and the disadvantages of a television course, would you take another one if it was something that you needed and it was at a convenient site?" Responses indicated that 96.1% would take another course. Clearly, the advantages outweighed the disadvantages for these students.

We had been told by other professors with television teaching experience that we would receive lower student evaluations from the off-campus students as compared to the evaluations from studio classes. When asked if we did a good job of explaining the course concepts and problems, 80% of the studio students said that we did, whereas 81.3% of the off-campus students felt this way. However, when the evaluations were completed, both of us were rated slightly higher overall by the studio students than we were by the remote site students.

Finally, although it is difficult to define or judge "success" or "achievement" in a course, we did compare the final grades of the campus classes with the remote site students in the finance class. Since the two subjects (finance and principalship) were very different, the examination methods were different, and classes were taught by two different professors, we did not attempt to combine or compare grades in the two subjects. In looking at the finance class, we found that students off campus achieved higher final grades. For example, the 12 students in the classroom had an average final grade of 3.25 (on a 4-point scale), whereas the 89 remote site students averaged 3.63 for their final grades. This should be interpreted carefully since there were only 12 students in the campus classroom, and the students at the remote sites may have been "better students" academically. It seems fair to say that the off-campus students did not suffer academically for having taken the course by television.

### Conclusion

The study found that our students had prior experience with television classes, with some students having had extensive experience. The "no-call-in" rule was considered reasonable by the students, and most of the on-campus students were not bothered by the phones ringing from the off-campus sites. Taking attendance took quite a bit of class time, but students, especially those on campus, felt that this process was appropriate. When asked about testing, students preferred whatever method they had been given, whether it was a paper test or a computer test. From time to time, there were problems with the technology, but these problems were not major for most students. Students other than BSU students took the television courses, pointing out potential recruitment benefits of this method of instruction. And, when asked the reason that off-campus students took the course by television, the overwhelming reason was convenience, driving to a nearby site instead of going to campus. Overall, the results seemed positive for our off-campus students: They received the same instruction as campus students for a lower cost (as compared to campus tuition), with no major technological problems, and at a convenient location. And, the on-campus students seemed to accept well the various technological requirements necessary for our off-campus students.

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## Flexible Learning Via Web-Based Virtual Teaching and Virtual Laboratory Systems

K. C. Chu and Dennis Leung

### Virtual Teaching System

In the current economic situation, most academic institutions would like to plan new courses to increase enrollment. Often, these changes do not follow with a proportional increase in cost or staff numbers to the institution. For cost-efficiency reasons, a reduction in student contact hours is most desirable, providing that this can maintain the quality of the learning experience. Web-based teaching is a possible and economical solution to this problem (Lee, 1999).

To implement Web-based teaching, the Department of Engineering of Hong Kong Institute of Vocational Education (Tsing Yi) set up an interactive virtual teaching system for the subject Logic System for students studying sub-degree engineering courses. Students are able to obtain updated teaching notes, tutorials, and

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digital video instructions through the Internet and displayed on a Web browser. Those Web-based programs will automatically correct students' answers for quizzes, and lecturers can obtain and monitor the students' feedback directly without any delay. The aim of the current design is to provide a more attractive and interactive environment for students to learn. The content of this virtual teaching package includes the following parts:

- Background information—Students can learn or review the fundamental concepts in this background section. The Web site also provides related materials such as aim and objectives, the syllabus, and booklists.
- Multimedia lecture on the Web (see Figure 1)—This section provide a place for downloading conventional lecture notes (in both Acrobat and PowerPoint formats) or viewing

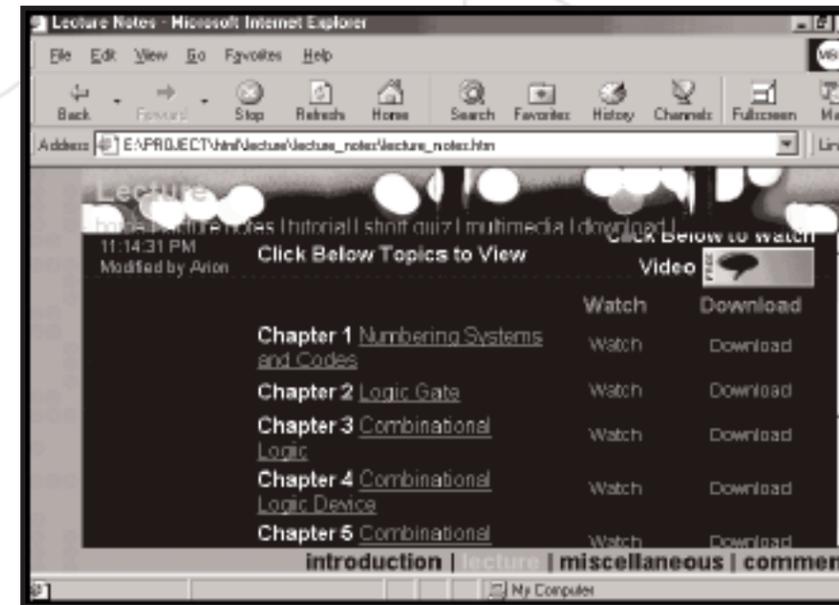


Figure 1. Multimedia lecture notes and explanation.

short video clips for better understanding of each topic. This multimedia approach attracts attention, generates interest to learn, and facilitates students' understanding. Students will be able to apply the theory learned to finish the assigned tutorials. To evaluate what the students have learned from the content, this section includes automatically marked short quizzes. Students must answer correctly a certain percentage of questions at the end of a chapter before moving on to the next chapter.

- Online discussion and related links—In order to simulate the classroom environment, this section provides an online chat room to allow discussion through the Web. Other functions in this section include Web linkage to IC manufacturers, downloading useful data sheets, links to other online lecture or tutorial sites, a search engine, and a glossary for detailed explanation for a particular term. These functions help students to obtain more theoretical and practical knowledge.
- Comment and guest book—Students can submit questions and suggestions to the Web-master through the easy e-mail system. They can leave or view comments on the guest book provided in this section. Such feedback can provide for further improvement for this Web-based teaching system.

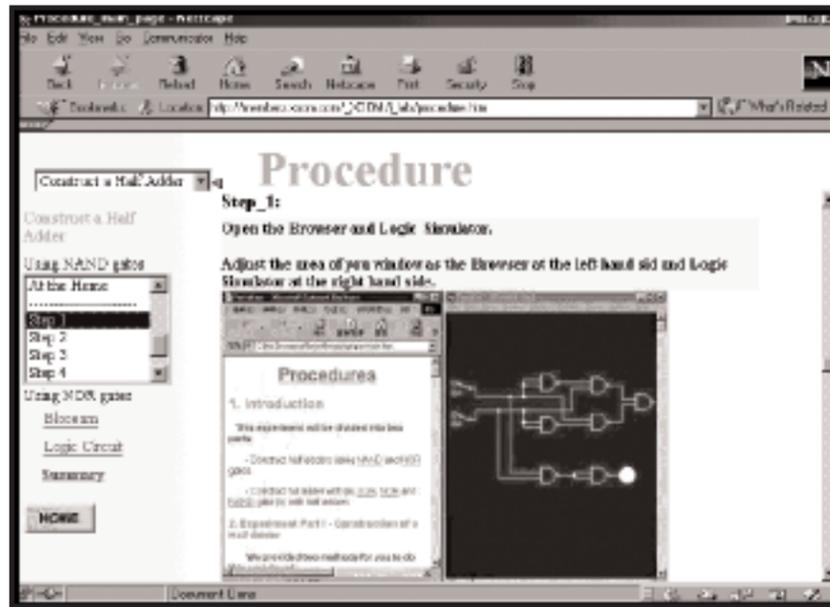
### Virtual Laboratory System

The laboratory is a very important part in engineering education. In fact, heavy weighting

in practical training dominates technical education (Leung, 1999). On the other hand, students must also understand a variety of rules, theorems, and devices that involve primarily knowledge-based learning. It is then the educator's job to let students learn to practically apply that knowledge through problem solving and design exercise (Ericksen & Kim, 1998). The virtual laboratory is particularly useful when an experiment involves equipment that may be harmful to human beings. The laser virtual laboratory developed by the Physics Department of Dalhousie University (Paton, 1999) shows how to operate a real time dangerous laser laboratory with the help of commanding equipment through the Internet.

The Department of Engineering of Hong Kong Institute of Vocational Education set up another virtual laboratory system for the same subject, Logic System, for the same group of students. The design of this virtual laboratory involves simultaneous use of the Web browser and any application package. Students are no longer limited to information provided by the prepared laboratory manual. Students can either conduct simple electronic experiments in the computer center on campus or stay at home to do experiments through their computers via the Internet. Students submit answers and comments for the laboratory through the Web. Lecturers can monitor the results of each student and immediately help students with problems.

Fig 2. Procedure for the virtual laboratory.



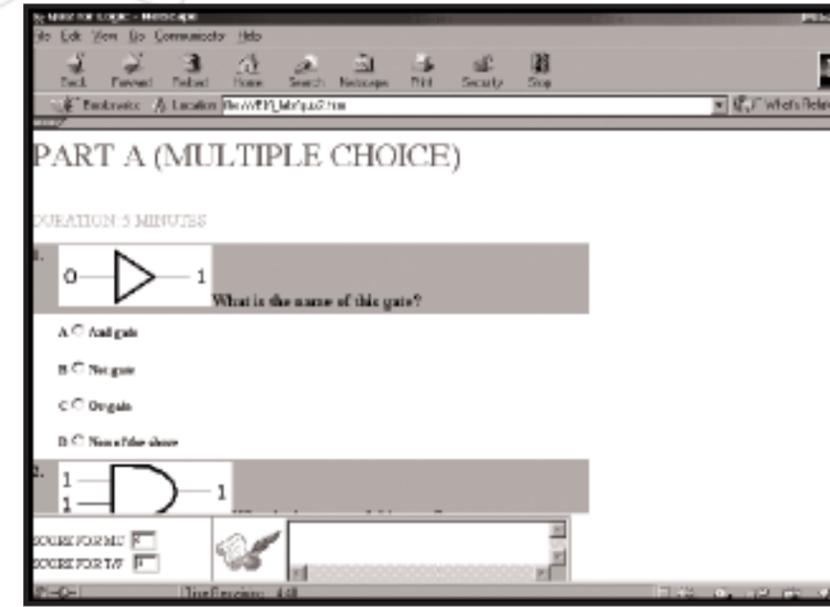
The current content of the virtual laboratory includes the following parts:

- Background information—This section contains all necessary basic concepts and theorems to perform experiments in the virtual laboratory. Students can save a lot of time finding necessary background information (e.g., theories of logic operation and simplification) to support their use of the virtual laboratory in different locations. They can easily review the basic knowledge learned in the class before going to the procedure section of the virtual laboratory or they can refer back to this section if they find something that is not clear.
- Multimedia explanation and demonstration—This section helps students understand the basic concept of the virtual laboratory by providing different video and audio aids that demonstrate the construction and running steps in the simulation environment.
- Download section for lab sheet, data sheet, and shareware simulator—Students can download lab sheets in this section and then follow the procedures in the lab sheets to perform the virtual experiment. The download area also provides students a location to obtain necessary utility programs (e.g., Adobe Acrobat) and simulation software (e.g., EasySim, MMLlogic). All of these soft-

ware programs are freeware or shareware.

- Step-by-step laboratory procedures—This section includes several experiments for students to perform via the Internet. Step-by-step descriptions, screen captures of simulation software (see Figure 2), and multimedia demonstrations provided in the multimedia section help students with less hands-on experience.
- Summary report and interactive quiz—This section consists of two parts. The first part is a lab report where students answer some questions related to the virtual lab, which provides a chance for them to write a summary report. Lecturers receive the summary report via e-mail. This arrangement provides immediate feedback to lecturers and a means to assess the performance of students participating in the virtual laboratory. The second part includes a quiz section with multiple choice (see Figure 3) and true or false type questions. These two quizzes allow students to review what they have learned in the laboratory. After completing the two quizzes, the screen displays the analysis of the quiz results. This analysis provides feedback to both students and lecturers.
- Online comment and feedback statistic—Students can offer their opinion for improving the virtual laboratory by selecting corresponding items (from excellent to bad) in the questionnaire. They can also leave mes-

Fig 3 Quiz section



sages on the guest book. Students and lecturers can easily check the questionnaire results (shown in bar chart) or take a look at the comments on the guest book.

### Students' Reaction

Eighty first-year engineering students at the Hong Kong Institute of Vocational Education tried the Web-based teaching and laboratory systems separately in a computer laboratory. In order to assess students' views of this Web-based approach, students completed a set of questionnaires immediately after their first experience of these systems in the computer laboratory. In addition, students freely wrote down their feedback to this study at the end of the questionnaire. The questionnaire's main purpose was to obtain students' views in regard to existing functions of the system, learning to use the virtual systems, quiz arrangements, and user interface, and to investigate the needs of students in the virtual environment. Finally, in order to find out how this virtual system approach might affect student learning and to obtain their views towards this new teaching approach, the lecturer randomly selected 8 students from this group of 80 students and interviewed them using open-ended questions.

According to the results of the questionnaire, most students showed a positive attitude towards the virtual systems and found that such systems encouraged and motivated them to learn better. Most students found it interesting

to learn through virtual teaching (VT; 89%) and performing experiments through virtual laboratory (VL; 88%). Some students related their interest in using VT or VL to their previous knowledge of Web browsing.

"I do not feel so interested as I am not familiar with browsing through the Web."

"I am not so familiar with the computer. So, I prefer to do experiments in a normal laboratory class."

On the other hand, other students who had suffered from previous hardware building experience found that VL was very useful for them to learn through this Web-based experiment.

"I feel that it is more convenient in performing the lab in this way. I do not need to find real electronic components in order to do the lab. I need not worry about loose connections of wires."

"It does not require me to set up equipment. I can know the results by pressing a button on the screen. I also know whether my design is working or not without constructing the circuit by real components."

Nowadays, a common phenomenon is that students have difficulty in learning and spend less time in studying. However, 60% and 67%

**Table 1. Feedback From Students Using Virtual Teaching and Virtual Laboratory**

Feedback	Virtual Teaching	Virtual Laboratory
Encouraged to participate	78%	82%
Motivated to learn	74%	92%
Software interacted well	83%	78%

of the students felt that it was easier to learn difficult concepts through VT and VL, respectively. The reason was that students found most information in the Web-based system or easily searched in the browser environment.

“It is easier to learn as these systems can contain hyperlinks to connect to a site so that we can get information that we need. We can also search information using the Web browser in the same environment. We can learn faster in this way.”

Students were more active in learning in a Web-based environment than in a conventional laboratory class. These Web-based systems encouraged most students (see Table 1) to participate during the process of using VT or VL and students claimed that they were motivated to learn the subject. Actually, students found that the software interacted well with them during the learning process. Moreover, students could review the VT or conduct the experiment again at any time by means of VL.

In the assessment part of these Web-based systems, 80% and 73% of students agreed that the quiz in VT and VL, respectively, could test how much they gained in the experiment. Also, 70% and 77% of students found that the quiz in VT and VL, respectively, could improve their understanding of the topic. Some students found that it was interesting to do the quiz.

“The quiz is interesting and provides us another channel to understand the content more.”

In the response to other questions for investigating the needs of students in the environment of Web-based systems, most students (90% for VT and 82% for VL) liked immediate feedback after finishing the quiz. This finding helped the developer of these Web-based systems to priori-

tize marking and giving feedback.

Also, students (>90%) reported the content should be more interactive. Video-conferencing, e-mail, and discussion groups can fulfill this requirement. Otherwise, students would find it boring if they just read materials provided in these Web-based systems.

“I find that it is more attractive, interesting, and easier to understand by using multimedia.”

“I like the video or movie more. I like to group information and select to read by pressing a button on the screen rather asking me to read many texts. Texts are boring.”

However, only a small percentage of students agreed that VT (35%) or VL (52%) could replace the normal class or practical laboratory.

#### Reflections on the Systems

The developer built these interactive virtual teaching and laboratory systems, and the sub-degree engineering students who used the systems provided valuable feedback. Actually, these nonstop systems can provide a multimedia learning environment to motivate students, promote a more active form of learning, offer more individualized and independent learning, and provide simulations of complex scientific processes that are less likely to be demonstrated in a normal class or laboratory.

The feedback from students confirms that they like this innovative learning and working environment and feel encouraged to learn better in this way. The fact that students do not have real face-to-face learning and hands-on experience with the senses are the drawbacks of these Web-based teaching systems. Actually, VT or VL is not going to replace normal teaching or workshops. They can provide a complement to traditional

classroom and laboratory resources (Chin, 1999; Chu, 1999; Lee, 1999). Through longer exposure, different assessment tasks, evaluation, and modification, the developer can improve the materials of VT and VL through these nonstop cycles of design, trial run, feedback, and modification.

#### The Future

There is the trend for tertiary institutes to increase student enrollment but without adding any staff. In order to overcome this increasing student-staff ratio and maintain the teaching and learning quality, universities or colleges could implement Web-based teaching and laboratory systems to reduce the workload of teaching staff and improve the learning outcome of the students. Future developments of these systems include:

- Integrating the virtual teaching and virtual laboratory (Waite & Simpson, 1996) to benefit students by presenting the same material in different ways and to exercise different learning styles. Our department is planning to build a scenario-based learning package (Chu & Leung, 2000) that will simulate a scenario similar to the students' future working environment. Students can virtually walk around and realize how the actual working environment should be. They can also take this opportunity to study how to operate and

interconnect different equipment. Students can use this virtual environment to better understand the operation and the theory behind the operation. Using hierarchical explanations can also suit the learning progress of students with different backgrounds. This scenario-based learning package will enable students to virtually immerse themselves in a scenario to enhance their learning and practical knowledge.

- Improving visual impact and reality of the existing VL system by real time captures the image and controls the instrument in the laboratory. Using virtual instrument control software such as LabVIEW (Ko et al., 2000), it is very easy to implement a real time remote laboratory system. In such a design, a more realistic feeling of controlling the remote instruments is accomplished by using a mouse to press control buttons or to turn knobs displayed on the screen. Users can observe any change of output from the real-time image sent from the remote site through the Internet.

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## A Curricular and Instructional Challenge: Teaching and Learning for Technological Literacy/Capability

James S. Levande

The role of technology education in the development of technological literacy and capability maintains a constant presence in, and at certain times and places, a point of debate within the field. This debate permeates all levels of the profession—from teachers selecting laboratory/classroom curricula and instructional strategies to institutions of higher education determining how to prepare technicians, technologists, and educators for K-12 and university programs to researchers seeking to establish sound theory and practice for the field. In these situations, as well as many others, views and perceptions are advanced to make a case for a particular focus on what constitutes literacy and capability. Usually this advocacy centers on meeting the needs of the immediate mission—teaching students at the K-12 level; or preparing teachers, technicians, or technologists; or developing the skills and abilities of postgraduate students to serve the diverse demands of research and continued development of the field. How is it then that an agreement can be reached about the similarities and differences between literate and capable when confronted with the scope of teaching and learning about technology across the places and times that students are engaged with technological studies?

The approach to consensus and agreement requires an understanding of the nature of technological literacy and capability, the establishment of a framework that will be inclusive of the many views and perceptions that are held within the many segments and focus areas of the field, and an application of the framework to meet the challenges of developing literacy and capability.

In understanding the continuing theme of developing technological literacy one only needs to go to the continuing discussion and development of the concept within the field of technology education. The fundamental point, that a person must know about technology and be able to do things technologically, is a continuing theme throughout the literature. This literature (Custer & Weins, 1996; Dyrenfurth, 1991; Todd, 1991; Weins, 1988) notes that there are diverse definitions of technological literacy and that these definitions frequently reflect the field or

discipline of the definer. However, one key element can be found in this diversity: It is the concept that a person must know about technology and be able to do things technologically.

The literature makes a series of key statements related to the relationships that exist between literacy and capability by:

- Linking literacy and capability. Capability is application, the use of technological knowledge (literacy) to solve practical problems through doing within the full curricular scope of the teaching and learning environment.
- Including curriculum integration by bringing together mathematics, English language arts, science, and social studies with the study and application of technology.
- Providing meaningful, personal realism where the impacts and consequences of technology can be confronted.
- Placing the learner in an active role at the center of achieving literacy and capability for whatever the purpose or mission at hand is.
- Placing achieving literacy and capability on a scale that delineates the increasing complexities demanded by the roles a person takes on in knowing about and using technology—scientist, technology teacher, technician, etc.

Compounding the literacy/capability issue is the specter of technological illiteracy. What are the consequences of not being literate and/or capable?

Here again the literature (Custer & Weins, 1996; Devore, 1991; Dyrenfurth & Kozak, 1991) within the field addresses the consequences of not developing technological literacy. Reasons included are democratic needs, the nature of life in society, dehumanization-humanization, and the nature of jobs-competitiveness-workforce literacy and where the impacts will be if literacy is not achieved. This illiteracy is described as impacting the quality of life and the natural environment in four ways: (a) the inability of citizens to function and contribute in

society, (b) the loss of competitive economic potential in business and industry, (c) reduced national security, and (d) economic and political disfranchisement of citizens. All of these points relate to the need for and the significance of technological literacy within society.

### The Challenges

A major assumption of this article is that the field of technological studies is committed to the development of technological literacy and capability as described in the literature. And, that the need for technological literacy and capability is essential to avoid a breakdown in the quality of contemporary life. A major problem exists in how this is to be accomplished. The problem's solution requires answers to the questions of: To what extent or degree should it be achieved at any given time and place? Where should it be achieved? and Who is responsible in achieving literacy and capability?

Streichler (2000) encapsulated the issues that revolve around the above questions by asking the field to establish a framework and formalize a continuum that addresses *technology* and the *learner*. The challenges that must be met in achieving the "continuum" include: changes in professional behavior; bringing segments of the field together; giving up past concepts and processes; and the quality, direction, and quantity of research in the field. The last challenge was further emphasized by the Technology Education Research Conference (Project 2061/American Association for the Advancement of Science [AAAS], 2000), the purpose of which was to think about a common strategy that would best support literacy goals, where it was pointed out that there is fragmentation in approaching the field's research agenda that is driven by discrete contributions without really impacting the educational system as a whole.

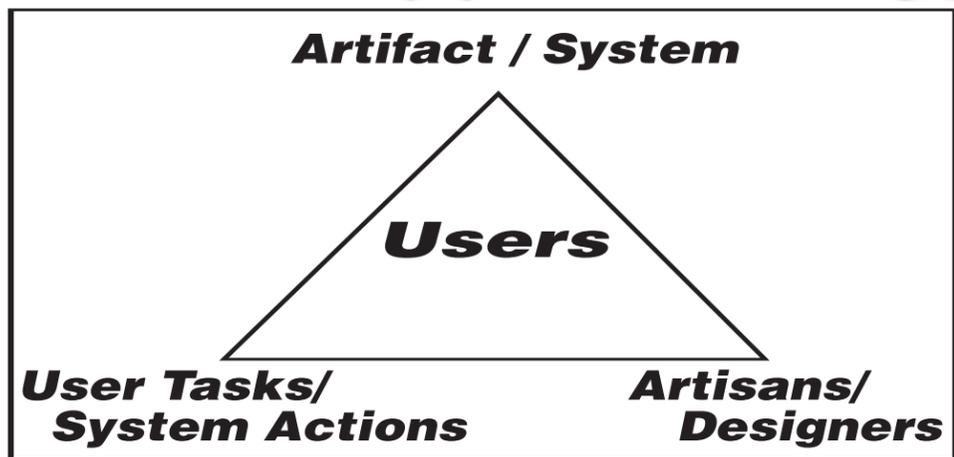
It is also important to note that the contributors to Technology Education for the 21st Century (Martin, 2000) touched on the theme of literacy, capability, and achieving a teaching and learning environment centered on the learner and learning. The essayists in this work, each in their own way, all touched on placing the learner at the heart of developing technological literacy and capability by describing exemplary practices that achieve it and in outlining an agenda for taking further action. This desire to

center on the learner is not new as is evidenced in the theme of the 1965 American Industrial Arts Association's (AIAA) national convention—"Developing Human Potential Through Industrial Arts" (AIAA, 1965).

With the existence of a segmented, multifocused agenda, the field will continue to define the notion of literate-illiterate to meet the diverse definitions and requirements of the specific contexts of each segment. A way to overcome the problems of segmentation and multiple focuses is to include all the viewpoints in one flexible, operable framework. The elements for this type of inclusive model are available within the discourse, research, and literature of the field. Agreement could be achieved on the basis of these elements and allow each of the segments or focuses in the field to deal with reaching the level of literacy and capability it believes is necessary to meet the needs of its constituency and society in general. This calls for a comprehensive, flexible perspective that gives everyone involved a common foundation, framework, and reference point. If the field cannot define and present this perspective on what technological literacy-illiteracy is, then it faces the danger of being unable to convince society of the need for technology education and technological studies.

Through its current discourse on technological literacy-illiteracy, the field has identified many required key components upon which to build the continuum and framework and meet the challenges identified by Streichler (2000). Basic standards are in place and a framework for achieving them is under development through the Technology for All Americans Project (1996). Higher level standards of technological literacy for trades people, technicians, technologists, engineers, and scientists are available through such sources as the National Skill Standards Board (NSSB) and the Accreditation Board for Engineering and Technology (ABET). Higher levels of technological literacy standards for teachers of technology, as set down by the Council on Technology Teacher Education and the National Association of Industrial and Technical Teacher Educators, are also available. There is recognition of the practical implications for the study of technology (Savage & Sterry, 1990) which include: balancing the "doing" and the cognitive dimensions; integrating knowledge with laboratory activities; including technologi-

**Figure 1. User-centered triangle.**



cal objects, artifacts, and systems within environmental contexts; distinguishing between technology and science; and defining the role of the human will within the technological problem-solving process. Placing the learner at the center of the process of technology education, and teaching and learning in general, is evidenced by the contributions in Martin (2000) as well as in the research and publications on the brain and learning, intelligence, designing learning experiences, and teaching that are available through the Association for Supervision and Curriculum Development (ASCD) and other professional organizations.

The elements serve as a basis for building a continuum. They address the range of diversity in opinions and beliefs held within the field about what constitutes literacy and capability. And, they comprise a set of essential working functions for a comprehensive, flexible continuum. These functions include:

- Adhering to a standards-based approach.
- Meeting the challenges of: changes in professional behavior; bringing segments of the field together; giving up past concepts and processes; and the quality, direction, and quantity of research in the field.
- Addressing the entire complexity of understanding and using technology in the complete spectrum of its application.
- Teaching and learning for literacy and capability that meet the required range of levels from that of a citizen in general to those of technologist, engineer, or scientist.

- Centering on learning and using technology in a “doing” setting.
- Placing the learner at the center of focus and application.
- Meeting the demands of preparing people for the complex roles required in the development and use of technology.

These workings comprise the framework to link segments together. Without the link the discussion and debate will continue to contribute to highlighting differences instead of emphasizing commonly held fundamentals.

**Standards for Technological Literacy: A Starting Point and Foundation**

*The Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association [ITEA], 2000) states what all people should know and be able to do with respect to being technologically literate in our global society. This should be the accepted starting point for all approaches to increasing literacy and capability. The standards identify the five key areas of technology—(a) the nature of technology, (b) technology and society, (c) design, (d) abilities for a technological world, and (e) the designed world—and set benchmarks within these areas as performance indicators.

Specifically, the standards state what a student should know and be able to do. The standards also provide for knowing and doing or process by describing the basic knowledge required for literacy and the abilities needed to act technologically. The associated benchmarks offer criteria to assess progress toward both cog-

nitition and process. The first three key areas—dealing with the nature of technology, society, and design—involve knowing. The remaining two key areas—abilities and the designed world—primarily address doing within contexts.

This article operates on the assumption that the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) sets a foundation and provides a platform to build increased levels of literacy and capability. And, it is recognized that standards for more advanced forms of technological literacy, such as those under the auspices of the NSSB and accreditation bodies for programs offering associate, baccalaureate, and/or advanced degrees in teaching technology, technical, engineering, and related fields, exist and constitute a more complex set of requirements for specific, in-depth forms of technological literacy that are built upon the basic standards. Without this agreed-upon starting point, the segmented, intrafield focuses on what constitutes literacy-illiteracy will have us running multiple races to reach disparate finish lines.

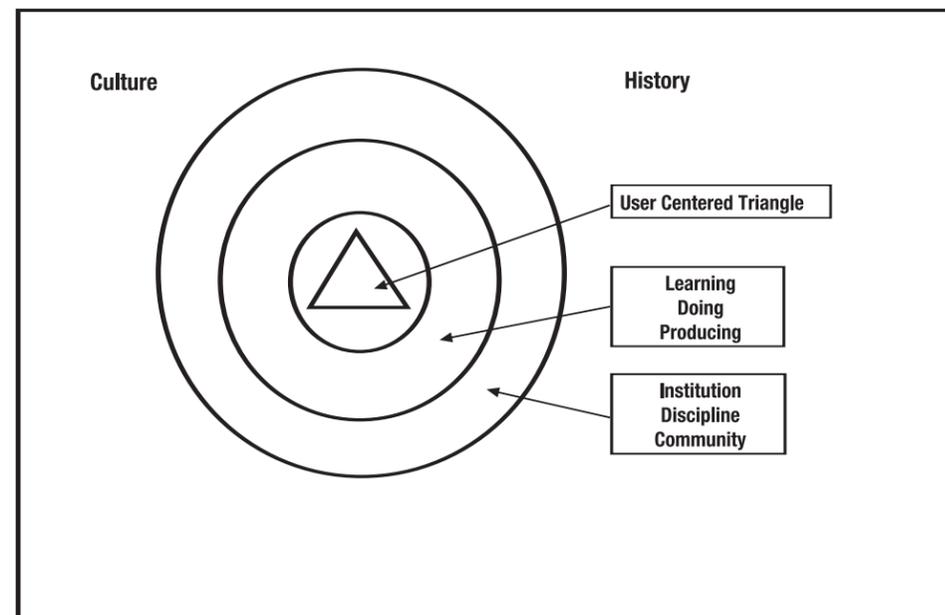
**A User/Learner-Centered Approach to Meet the Challenges for a Continuum**

Where can a flexible, operable model that brings all the elements together be drawn from to provide the framework and continuum? Streichler (2000) suggested that the field turn to

the formulations offered within the literature to achieve the “continuum” goal. In taking up this course of action, and to include the professed values of technology education, the field may have to step “out of the box” to reach a consensus. The rationale behind this approach is based on giving equal consideration to all the viewpoints and avoids the appearance of giving precedence to any one segment.

Many other fields of study and practice face similar challenges in dealing with the complexities of technology. Turning to the points of view of these other fields permits a perspective or “out of the box” view of technology education’s situation. One such view comes from the field of communications. Here the communicator, usually a writer, is faced with the job of interpreting the use and application of a tool, artifact, and/or system for the purposes of enabling the user to accomplish a technological task or function. The writer relies on the discipline of rhetoric. This is not the rhetoric commonly associated with the use of language as a means to deceive that comes to us from Socrates’ descriptions in the *Gorgias* or *Phaedrus*. Nor is it the use of exaggeration or display in language often associated with political campaigns. It is a collection of techniques that makes the production and dissemination of language a strategy by which the writer achieves the purpose of turning the reader into a func-

**Figure 2. User-centered complex of technology.**



tional user of the tool, artifact, and/or system. This latter definition as strategy is a process as much as the process of house building. The end of house building is not the house itself or the builder's use of the completed structure, but rather the use made of the house by those for whom it was constructed.

Johnson (1998) took the above notion of rhetoric as a strategy and applied it to achieving a user-centered approach to technology where humans who interact with various technologies (systems, simple hand tools, appliances, complex electronic networks, etc.) are the primary focus. He pointed out that technology has too often been focused on either (a) the interest of the developers who hope to gain from it, (b) the interest of the disseminators who hope to reap the fruits of its success, or (c) those who develop and release a technology into the public sphere with little or no concern for its intended or unintended consequences.

Johnson (1998) argued that it is the demands of the technological artifacts and systems that drive design and innovation. Human factors are too often left out of consideration in the design and use of technology. His basic premise was that because humans use and apply technology it is necessary to place them at the center of all interactions that involve technology. To remedy the oversight of human factors, he offered the "user-centered complex of technology." This view offers the field of technology education an operable model capable of meeting the requirements of a continuum that prepares people for understanding and using technology in the complete spectrum of its application.

The user-centered complex describes the relationships between users of technology and the designed/created world. The complex is made up of the following elements: (a) artisans and designers, (b) artifacts and systems, (c) user tasks and system actions, and (d) the user. The first three elements are dimensional in form. They can be seen as scaling from one end to the other (i.e., artisans/designers; artifact/system; user tasks/systems actions). These elements are configured in a triangular structure with the first three dimensional elements at the vertices while the fourth element, the user, and for the ends of technology education the learner as well, is placed at the center of all interactions (see Figure 1). For the purposes of this article, user and learner can be considered to be syn-

onymous and interchangeable. All future references to the user will be referred to as user/learner.

The employment of a triangle as a taxonomic device ensures that any one element is always in a direct link with any of the other elements. These links are considered to be dynamic. The sides of the triangle indicate the process of exchange that occurs among the elements. Finally, this triangular, dynamic user-centered complex is set within the shells of learning, doing, and producing; community, discipline, and institution; and culture and history (see Figure 2).

The dimensional elements (artisans/designers, artifact/system, user tasks/system actions) are characterized in the following manner.

*Artisans/designers* are viewed as "creators" of technology. *Artisan* represents the maker of tools, artifacts, and some forms of technologies while *designer* defines the engineer and in some cases the scientist (in the sense of scientist as a participant in the construction of technologies). Teachers of technology, technicians, and technologists can be considered to stand somewhere in between the two ends of this dimension. It is important to note that all the roles in this artisan/designer element often switch places and that the artisan takes on the functions of the engineer and vice versa.

*Artifact/system* defines the "constructs" of technology. *Artifacts* are simple technologies—tools, products, prototypes—created and used independently of other tools, products, and prototypes (at least in any direct physical way). *Systems*, or complex technologies, are usually artifacts physically connected either mechanically, electronically, or in some other direct, interactional manner. Systems can also be viewed as "nonartifactual" technologies such as organizations or networks.

User tasks/system actions are the "contextual subject matter" of technology. User tasks represent technology's actions as perceived by the user/learner. System actions are technology's actions as perceived by the artisan/designer.

The key completing element in the complex is the *user/learner* of technology, who is placed at the center of the other elements, at the heart of the dynamic, collaborative interactions of the other elements.

No technology is developed, disseminated, or used in a vacuum. The user-centered complex operates within the shells of learning, doing, and producing; community, discipline, and institution; and culture and history as depicted in Figure 2. These shells provide the situations and constraints that form the user/learner as well as the artifact/system, user tasks/system actions, and artisans/designers.

Learning and doing, as part the first shell or layer, is where the user/learner is engaged in the design, dissemination, or end use of technological systems or artifacts. Producing, the third component of this shell, engages the user/learner in applying knowledge and skills as a practitioner and producer. This is not just a tool-use model describing user knowledge and ability from a tool-centered, artifact-centered, or systems-centered perspective, because the knowledge and skills of technology are assumed to be in the technology, not in the user/learner. If one accedes to the definition of learning, doing, and producing of a tool-centered model, then one accepts that the knowledge and ability of technology is put there by designers or inventors, not by users/learners. Placing the user/learner in the role of producer entails accepting the user/learner as capable of being an artisan/designer of technology. This also recognizes that users/learners bring the human factor into technological decision making.

The next outward shell constitutes the human networks that constrain technology. These networks—*disciplines*, *institutions*, and *communities*—probably do not make up a complete list, but do cover much of the territory at this level. These networks easily overlap and create complexes within and among themselves. One example is our own field of technology education or technological studies. Within this discipline there are overlapping communities that are working to achieve numerous missions—general technological literacy for all people, entry-level and continuing career preparation, pre and in-service professional development of teachers, etc.

The outermost shell comprises the factors of *culture* and *history*. These two factors are often invisible but they should not be ignored. Cultural forces define nearly every human action, and in a world more dependent than ever on international communication and technology

transfer, the factor of culture becomes essential when defining the use of technology. History, integrally related to culture, refers to the reflective aspect of understanding human action, particularly in terms of responsible, ethical behavior. History informs the understanding of technology in unique and fundamental ways.

Johnson (1998) offered that this "complex" serves the purposes of analyzing technological artifacts and processes; exploring the people who use, make, and/or even destroy technology; helping to examine those who are enamored and/or bored with technology; and studying the user/learner actions within the complex.

### Application of the User/Learner-Centered Approach to the Challenges

How does this user/learner-centered approach apply to the mission of developing technological literacy and capability? The application is based on Johnson's (1998) purposes, primarily studying the user/learner's actions within the complex, but also including the examination of artifacts, systems, design, and human behavior and conditions surrounding using, making, and even destroying technology. In this sense the entire complex serves as a framework or structure for the continuum called for by Streichler (2000). It addresses the challenges by (a) providing for all forms of behavior—including that of users, learners, and professionals—within the field, (b) providing settings where all segments of the field can function in association and collaboration, (c) considering past (historical and cultural) concepts and processes, and (d) providing a research frame of reference with which to gauge a point of interest, debate, concept, and/or process with any other point within the continuum. Most of all it provides a place where the essential working functions described earlier in this article can be included and addressed.

Let us take these four challenges and apply the user-centered complex to them one by one.

#### Behavior

At any one time a person can take on a multiplicity of roles within technology and technology education. The complex provides for these roles and permits moving freely between and within them. These roles take place in one or more of the shells or layers of the user-centered complex. As a user/learner, designer,

and/or artisan one is primarily involved with learning about and using, doing, and producing with technology. As a teacher and educator one is engaged in conveying the needs, wants, desires, and values of the community, discipline, and institution as they relate to technology's use, production, and application. As a researcher one is exploring, documenting, and formulating the relationships that exist between and among all aspects of the complex from the cultural and historical right down to the more detailed aspects of learning, using, doing, and producing.

Moving from the center of the complex to its outer shell requires one to engage in a number of behaviors. First, acceptance of the concept that technology and technology education exist in an inclusive, universal system imbedded in and encompassed by all of the shells of the complex. Second, through reflection and study, identifying where one stands within the complex with respect to personally held beliefs about each and every element—systems, artifacts, learning, doing, producing, tasks, actions, etc. Third, employing behaviors that embrace a greater and greater amount of willingness to respectfully consider other beliefs and viewpoints, relate one's view to those held by others, and to collaborate in, and establishing where mutual benefits can be achieved for the common good of technology education. And, fourth, promoting and advocating for one's personally held beliefs by placing them within the shells and relating them to all elements of the complex through sound research constructs, methodologies, and documentation.

Various perspectives on what constitutes the types of appropriate professional behavior presented above are found in Gilberti and Rouch (1999). A majority of the contributions to this work, all of which advance various aspects of a framework of professional behavior, are devoted to defining professionalism, identifying opportunities for improvement, and describing model professionalism at various educational levels. It is in the final chapter of Gilberti and Rouch's book that Devier (1999) provides a vision of a desirable professional culture. A vision that recognizes the necessity of individuals possessing a general systematic knowledge of the profession of technology education. This systemic knowledge of the profession furnishes a basis for aligning with the systemic nature of the user-centered complex. This culture of technology

education professionalism can be found embedded in the general culture as well as in the networks of the disciplines, segments, and focuses of the field that surround the actions and elements grouped in the center of the complex.

The challenge of changed behavior should be considered as a primary and foundational action for use of the user-centered complex. Meeting the other challenges relies on the appropriate behavior.

#### **Setting**

The complex, through its elements, provides locations where individuals as teachers and teacher educators can "hang their hats." Teachers can choose to emphasize and promote designing and producing artifacts and/or systems or place stress on user/learner tasks as opposed to system actions within the contexts of the curriculum and programs for which they are responsible. Using the elements to provide a holistic view of the complex of technology, teacher educators can then proceed to stress those things that are necessary to prepare students to meet the standards of certification for specific areas—K-12 general education, high school career and technical preparation, postsecondary technologist training, or higher education at the baccalaureate and graduate levels. The basic requirement is that they, and this goes back to behavior, recognize and accept that the emphasis, promotion, and stress take place within the complex. Rejection will, at the least, create a self-imposed isolation within the complex and at its extremes result in a disruption of the continuum leading to segmentation and disunity.

#### **Past Concepts and Processes**

The field cannot escape the fact that current and future concepts and processes rest on that which has happened in the past. The historical and cultural elements provide a location to address the issues that revolve around the inclusion of past concepts and processes without ignoring or eliminating them. Set within the complex, the concepts and processes of technology can be considered to the degree necessary to achieve the desired educational outcome. At a minimum it may only be necessary to cite the lineage of a contemporary concept/practice to reach a standard or benchmark. In other instances including the past concept/process may be needed to build required contemporary knowledge and ability. And finally, emphasis and in-depth use of a key past concept/process

may be the only avenue to achieve a very high degree of knowledge and ability that is essential in a particular technological application. The complex's historical and cultural elements coupled with the elements of institution, discipline, and community provide two mechanisms to deal with the past—"handles" to grasp the placement and significance of the past in relationship to the present practices and "platforms" to launch forecasts and speculation on where any concept/process may lead to.

#### **A Research Frame**

The entire complex provides a context that permits a hypothesis to be framed in a manner that can display its linkages to all elements of the technological setting. History and culture; discipline, community, and institution; learning, doing, and producing; artifact/system, user task/system action, and artisan/designer; and, most of all, the learner/user constitute places on the continuum where questions can be focused. Granted that the nature of research requires one to consciously and deliberately structure and focus the process of questioning to achieve specific answers within a range of probability. However, the process of questioning does not obviate the milieu in which the research takes place. Basically, the complex provides parameters that prompt consideration of a question within the milieu.

#### **Meeting the Remaining Essential Working Functions for a Continuum**

The user-centered complex, because of its inclusive nature, can accommodate the other remaining functions for the establishment of a continuum. Let us examine each in relation to its place in the complex.

#### **Understanding and Using Technology in a Spectrum of Application**

Addressing the entire complexity of understanding and using technology in the complete spectrum of its applications can take place by focusing on the elements of the model. The elements provide specific places and contexts for the application of technological understanding and ability. The elements of the shells and the triangle can be associated with activities ranging from the general to the specific, from basic cognition to in-depth understanding, and from a use of modest technical abilities to that of very highly refined levels of ability. The user tasks, system actions, designing and/or producing, as well as working within the networks of discipline,

community, and institution, all come into play.

#### **Teaching and Learning for a Range of Literacy Levels**

The networked elements within the complex of community, institution, and discipline provide settings for accomplishing teaching and learning for literacy and capability that meet the required range of levels from that of a citizen in general to those of teacher of technology, technologist, engineer, or scientist. A citizen, in general, may never be required to go beyond the need to know about those things technological that are necessary to preserve our democratic society, while this same citizen, as a productive worker, will be required to know about and be able to do things with particular technologies in order to continue in and perhaps advance him or herself in his or her job or career. Taking this scenario a step farther one can go to those jobs, careers, and professions that are specifically technological in nature. Here in-depth knowledge and abilities ranging from designing and producing a particular artifact right on through to systems design and application are required. All can be taught in appropriate settings and at a designated time provided by the situations and constraints of the complex.

#### **A Setting of "Doing"**

Centering on learning and using technology in a "doing" setting is evident in that the complex explicitly includes this essential activity. Learning and producing cannot be achieved in a passive manner. If one were to remove doing from the complex, it would destroy the learning and producing elements of the structure.

#### **Learner Centered**

The heart of the complex is the learner at the center of focus and application. Everything depends on the presence of the learner/user. Johnson's (1998) theoretical constructs are based on this most primary concept. The reality of leaving the learner out not only destroys the complex, but it destroys the whole notion of providing any form of education whatsoever.

#### **Preparation for Complex Technological Roles**

The rationale for "teaching and learning for a range of literacy levels" also applies to meeting the demands of preparing people for the complex roles required in the development and use of technology. The situations and constraints of the model provide the appropriate settings for achieving the complexities associated

with the various roles a person plays in a technological world. The complex answers the demands placed on it by accommodating to meet the level of literacy required to perform a technological role, be it elementary or in-depth.

### Who Is Responsible in Achieving Technological Literacy and Capability?

The user-centered complex of technology offers one way of dealing with the questions: To what extent or degree should literacy and capability be achieved at any given time and place? and Where should it be achieved? The answer to these two questions provides an indication of the framework's parameters to be dealt with in a holistic continuum. It does not directly address "who" is responsible.

The "who" responsible is every individual in the field of technology education and technological studies. This means that, by engaging in proactive professional behavior, we all begin to recognize, endorse, and promote the systemic, holistic nature of technology and the development of technological literacy and capability within a framework such as the user-centered complex of technology.

The problem may be that we have been looking at any one individual segment of the field as if this perspective is the only view and then promoting this perspective as a definitive model. In the field of physics this concept is termed a *duality*. A duality exists when models appear to be different but nevertheless can be shown to describe the same thing (Greene, 1999).

Dualities are of two types. The first is when ostensibly different models are actually identical and appear to be different only because of the way they happen to be presented. An example of this would be if someone only fluent in English were to describe the process of turning but would be unable to recognize the description if it were presented in Chinese. A person fluent in both languages could easily perform a translation and establish their equivalence. Then second is when distinct descriptions of the same thing do present different and com-

plementary insights. In this instance, where dual (or multiple) descriptions are provided for a single universe, in our case technological literacy and capability, important insights that follow from using dual descriptions can be achieved. Both types of dualities are resolved through an acceptance of a universal, systemic domain in which translations can be made and dual insights be accepted.

Solving this problem of looking at individual segments of the field as if each perspective is the only definitive model could be addressed through the application of the user-centered complex of technology. The complex provides a way of addressing the field's diverse segments and missions while maintaining a universal, systemic framework for developing technological literacy and capability. In addition, the complex meets Streichler's (2000) call for a continuum in that it describes a framework in which a fundamental common character—technological literacy and capability—is discernable amid a series of variations.

### Next Steps

Where does technology education go next in the use of this user-centered complex of technology or any other model similar in nature? If this approach is accepted, then technology education must continue to (a) define, develop, practice, model, and teach the proactive professional behaviors that hold the continuum in place and (b) extend knowledge and practices that clearly define, characterize, and promote all the elements within the complex. The field has numerous forums for achieving both of these initiatives. They include the Mississippi Valley Technology Teacher Education Conference, the International Technology Education Association and its councils, the *Journal of Technology Studies*, and the *Journal of Technology Education*. Through these forums the ideas and concepts can be refined, directed, and applied in a meaningful manner.

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## A Senior Course in Design for Manufacturability

Bernie Huang and Joseph C. Chen

In today's fast-paced world, everyone is looking for the leading edge to become, and stay, competitive in the market. To garner market share, the product must satisfy and delight customers. To achieve this objective, design becomes one of the most important aspects for the product. Design is the first and fundamental step in building and constructing everything. The cost to operate the design department in each company may contain only 5% of a company's budget. However, 70% of the final product costs are influenced by the design (Boothroyd et al., 2002). In today's competitive market, the customer demands a good design with a competitive price. Therefore, in order to compete successfully, the customer has to be satisfied. With a good design, up to half of customer demand has already been fulfilled. Furthermore, a good design can also help enhance quality of the part, increase productivity, and reduce costs in manufacturing and assembly processes.

A manufacturing system is a complex arrangement of physical elements, such as machines, tools, people, and material handling devices, which could be measured by the production rate, inventory level, or percentage of defective rate (Black, 1991). Although the research and design department is not generally within a manufacturing system, the interactions between design and the manufacturing system significantly affect product cost, product quality, and productivity within a company. Therefore, a knowledge of design for manufacturing (DFM) has become a new trend for manufacturers and demands that technology educators include DFM content in their existing design curriculum. According to Boothroyd et al.

(2002), DFM is concerned with understanding how product design interacts with the other components of the manufacturing system and in defining product design alternatives that help facilitate global optimization of the manufacturing system as a whole.

In 1995 the American Society of Mechanical Engineers (ASME), with funding from the National Science Foundation, published the results of a study that examined curriculum changes needed to more effectively integrate elements of the product realization process into the education of engineering or technology students (Przirembel, 1995). The premise for this study was the realization that the lack of manufacturing and design capabilities in U.S. industry today is a critical factor in the decline of

the nation's international competitiveness. Sixty-six senior managers from 33 companies were asked to rank a list of 56 different "best practices" as to the importance of each topic to both new mechanical engineering graduates and experienced mechanical engineers. In addition, this same list of best practices was sent to all accredited mechanical engineering departments in the United States where academic representatives were also asked to rank these topics in order of importance. Teams/teamwork was selected by over 90% of the industry respondents and the academic respondents. Eighty-eight percent of the industry respondents indicated that DFM was somewhat important or very important.

The team approach allows all employees who are working on a product

to act as one team in order to achieve the common goal of manufacturing a quality product in less time and at reduced costs. If a company wants to develop a world-class manufacturing operation, it has no choice but to view design and manufacturing as a single conceptual process, which DFM can do. DFM is a cutting-edge improvement program that can reduce labor, material, and mass requirements without sacrificing the integrity of product or process (Boothroyd & Dewhurst, 1990).

In industrial manufacturing, metal casting and plastic injection molding processes are the two most common and most important techniques used to produce parts. Both techniques are used in creating the basic profile of products for advanced manufacturing processes. Before casting and injection molding can be done, a proper mold has to be designed. A good mold design can improve the ease of manufacturing and enhance the quality of a part. Therefore, the conception of designing a good mold becomes very important (Cheremisinoff, 1990).

The purpose of this study was to develop a practical curriculum module to communicate the ideas of DFM. This curriculum is designed for students at the senior level. Since students have a strong background of industrial technology (IT) in the design and manufacturing phases, knowledge of DFM will enhance the students' ability to involve themselves into the strategic planning level in their future employment. For the stu-

dents of IT, an understanding of DFM becomes very important for them to integrate the knowledge of design principles and manufacturing processes. This curriculum will help students understand how DFM works in the industrial field and how to construct a new product from design through the manufacturing phase.

### DFM Curriculum Module

The DFM curriculum module integrates the design principles, the design of injection molding, cost analysis, and the manufacturing processes. Figure 1 shows the architecture of this module. The goal of this curriculum is to assist students in creating a new product. The principles of DFM are applied to generate the idea of the new product.

The curriculum development of DFM can be separated into four units, which contain both lecture and laboratory sessions.

**Unit 1—Design principles:** The objective of this unit is to illustrate the importance of design and DFM. To this end, 3D AutoCAD drawing technology is applied to assist the product design.

**Unit 2—Die and mold design and analysis:** The objective of this unit is to focus on the design and analysis of injection molding. The design principles of injection molds are discussed first to generate the ideas of designing an injection mold. The application of C-mold software is the focus of discussion in this unit. C-mold software is a powerful tool used to analyze the mold design for

injection processes. It can analyze the pressure, temperature, cooling system, molecular orientation, weld line, and air trap of the injection mold before it is fabricated.

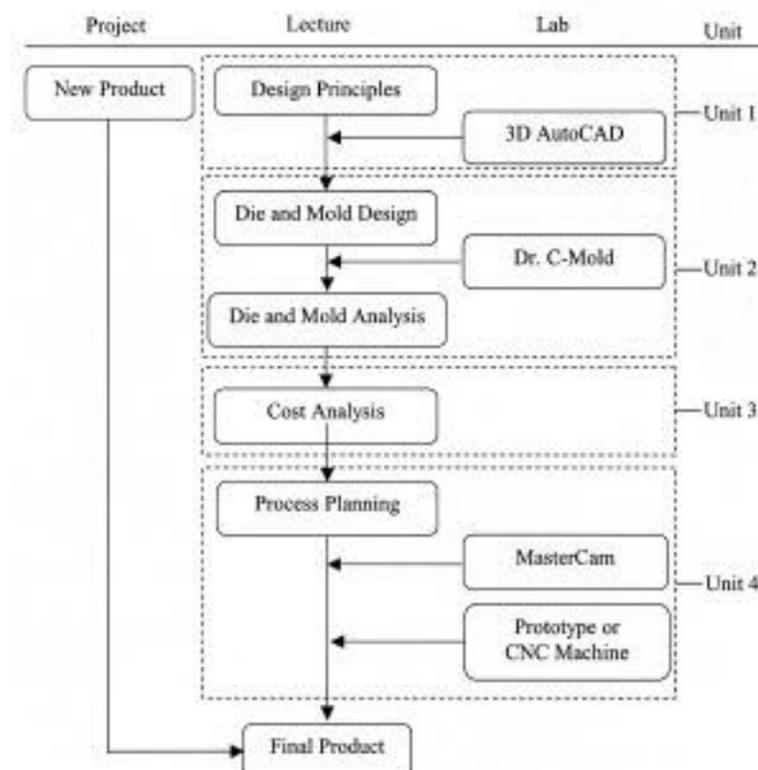
**Unit 3—Cost analysis:** The objective of this unit is to estimate the cost of fabricating the product. The differences between fixed and variable costs are introduced for the preparation of total cost estimation. The principles of engineering economy are applied to estimate the total and unit costs, identify the break-even point, and decide the proper price for selling. In the discussion of engineering economy, a cash flow diagram and interest formulas relating present and future equivalents and also annuity to its present and future equivalents are focused on to understand the method of cost estimation.

**Unit 4—Process planning:** The objective of this unit is to discuss the proper machining processes for manufacturing the die and mold. How to optimize the machining parameters for milling operations, such as spindle speed, feed rate, and depth of cut, are discussed. The MasterCam software is applied to create the tool path of a 3D model and then generate the NC program. Finally, the NC program is installed in a CNC machine to cut the mold.

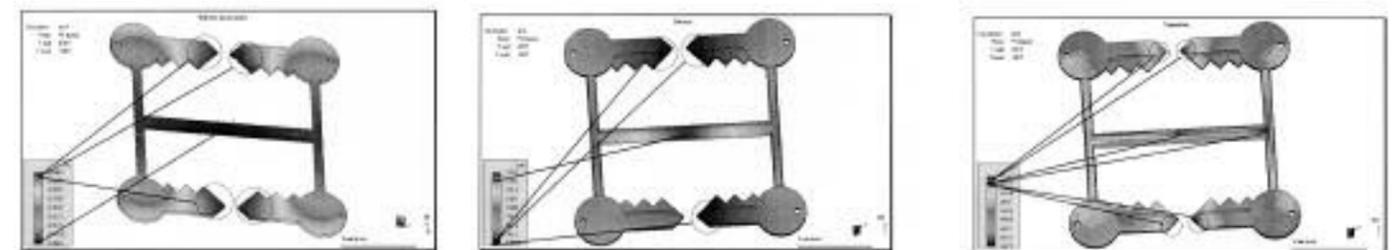
### Case Study Identify Needs

Several items needed to be considered in designing the product. The first item was to understand the need of the

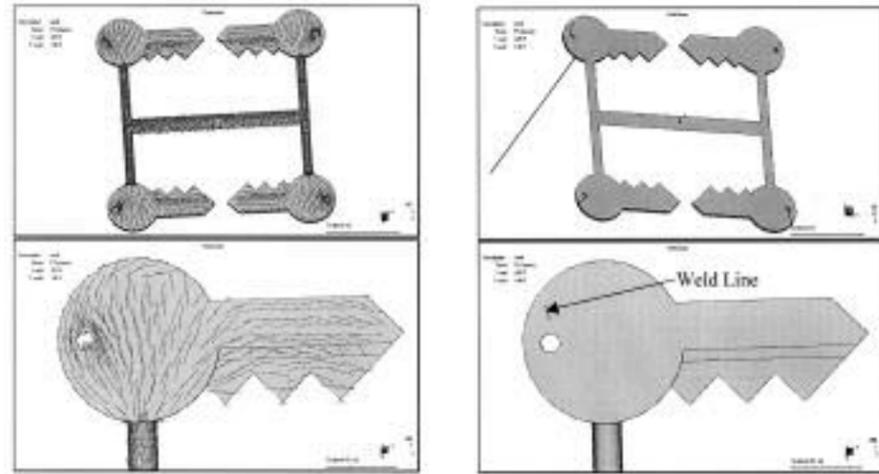
**Figure 1. The DFM curriculum module.**



**Figures 2, 3, 4. Results of melt front advance (2), pressure (3), and temperature analysis (4).**



**Figures 5 & 6. Results of molecular orientation analysis (5) and weld line analysis (6).**



customers to decide the design of the injection mold. Basically, the product had to be inexpensive to make, manufactured in large numbers quickly, and something that Iowa State students would like to have. With these considerations in mind, we decided to make small key chains with Iowa State printed on them.

This product fit the criteria we were looking for. Once the product was decided, the design of the injection mold was considered. To quickly produce a lot of key chains, a mold with four keys was designed for this project.

#### Die/Mold Design

The next decision was to decide what program should be used to translate the free-hand sketch to create the blueprint for further application. AutoCAD software was applied to draw the design. We chose AutoCAD because it has very good drawing capabilities and it is also very easy to export the file created by AutoCAD into MasterCam for future cutting path generation.

#### Analysis by C-Mold

The next step was to analyze the characters of the mold. C-mold software was applied to analyze the characters of the designed injection mold. The following steps indicate the results of each character of this mold.

*Step 1—Analysis of melt front advance:* The results of the melt front advance (shown in Figure 2) simply show the flow of the molten polystyrene at the completion of the injection stage. This graphical analysis allows the user to determine if the cavity or cavities have been completely filled or if a short shot has occurred. This also shows the user if any voids have been left in the part. The time required to fill each section of the cavity can also be determined by this analysis. The dashed circles indicate the corresponding time of the scale located inside the lower left corner of the figure.

The analysis of the melt front advancement for our design was ideal. The melt front advancement was equal in all four cavities for all times, indicating

that the design was well balanced and that there should be no problems filling or over packing the mold. Also, the time required to fill the mold was relatively short, leading to a low cycle time.

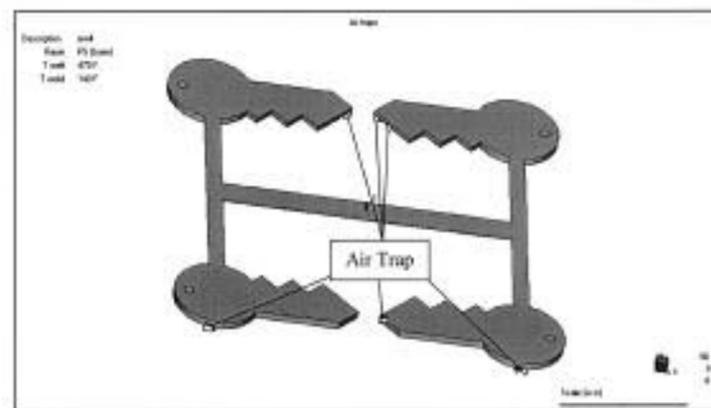
*Step 2—Analysis of pressure:* The pressure analysis (shown in Figure 3) indicates the amount of pressure at specific parts of the molded part at the end of the injection cycle. It is ideal to have a gradual increase in pressure at the injection point as the part begins to fill.

The analysis of our design was acceptable. We had a maximum pressure reading of 2018 psi at the injection point. The other parts of the design had a gradual reduction in pressure as the flow length increased. This was not a problem because there was not a large amount of variation in the pressure readings of each cavity (approximately 500 psi).

*Step 3—Analysis of temperature:* The temperature analysis (shown in Figure 4) points out the spatial temperature variation throughout the part at the end of the injection stage. Generally, the greater the variation the greater the amount of warpage that can be expected.

The analysis of our design showed an overall temperature difference of 2.5 °F. With such a small change in temperature distribution, we expected to have a part with little or no warp.

**Figure 7. Result of air trap analysis.**



**Table 1. Summary of Cost Estimation**

Cost Item	Total Cost	Annual Cost	Frequency per Piece	Unit Cost
1. Machine	\$45,000	\$14,376*	50,000	\$0.2875
2. Die and mold	\$4,500	\$1,440*	50,000	\$0.0288
3. Design & analysis	\$480	\$160*	50,000	\$0.0032
4. Maintenance		\$1,000	50,000	\$0.0200
5. Setup		\$60	50,000	\$0.0012
6. Machining	\$20/hr	\$2650	50,000	\$0.0530
7. Material	\$0.7/lb		0.2 oz	\$0.0200
<b>Total unit cost</b>				<b>\$0.3937</b>

\* The interest formulas relating present and future to its annuity equivalent values are applied to calculate the annual cost (Paul Degarmo et al., 1997). The effective interest rate per interest period is set at 20% and the service life of this product is 5 years.

**Table 2. Matching Parameters and Sequences**

Sequence	Description	Spindle Speed	Feed Rate	Depth of Cut
1	Rough cut the whole mold (1/4" end mill tool)	2290 RPM	15 in./min	0.050 in.
2	Finish cut the key part (1/8" end mill tool)	4580 RPM	5 in./min	0.010 in.
3	Finish cut the running system (1/8" ball mill tool)	4580 RPM	5 in./min	0.010 in.
4	Finish cut the letters (V-mill tool)	8000 RPM	5 in./min	0.005 in.

*Step 4—Analysis of cooling:* The cooling analysis provides information about the time required for a material to reach its heat deflection temperature based on the design. This is important because cooling time is the most time-consuming stage of the injection process. The ability to optimize the cooling time by changing the mold design can be achieved through this analysis.

The analysis of our design revealed virtually no difference in the cooling time for any part of our design. We achieved this by keeping a uniform thickness throughout the part whenever possible.

*Step 5—Analysis of molecular orientation:* The molecular orientation analysis (shown in Figure 5) shows the orientation of the polymer molecules on the surface of the part at the end of the filling stage. Essentially, extreme differential of orientation will cause a differential in shrinkage, thus causing the part to warp.

The analysis of our design showed a gradual change in the direction of orientation in our parts. This was a critical issue along the flow path of the key, where the part would be likely to warp. However, the molecules orientated along the flow path of the key were almost parallel to each other.

*Step 6—Analysis of weld line:* The weld line analysis (shown in Figure 6) provides the formation of weld lines during the simulation. This information can be used to relocate weld lines and to eliminate them. Malloy (1994) defined weld lines as follows: "Weld lines (or weld planes) are formed during the mold filling process when the melt flow front separates, and recombines at some downstream location" (p. 47). Weld lines look like cracks on the surface of the molded part and generally are the weakest areas having potentials of failure.

The analysis of our design showed four weld lines for our design. The weld

lines were caused by the hole in the end of the key. This was of some concern to us because a key ring was to be put through the hole, applying force that would cause stress on the weld line. To handle this slight problem, we had two options. First, for the small price that the part would sell for, long-term reliability was not an issue. Second, we could have found a low-cost semi-crystalline material that was not as sensitive to the structural inferiority at weld lines associated with amorphous materials.

*Step 7—Analysis of air trap:* The air trap plot (shown in Figure 7) shows the areas of the design that may require venting. The plot shows the areas where air is likely to be trapped inside the mold. If the air is not vented the possible defects are short shots, or burn marks, on parts.

The analysis of our design showed that we needed to vent our mold at two areas on each cavity. This was not a problem or of any concern, as all molds

have to be vented to allow air to escape.

### Analysis by Cost

As the design and analysis of the injection mold was finished, the next step was to estimate the cost of production and make an evaluation of the sale price of each product. For design and manufacturing engineers, the analysis of alternative production methods of a part, or a product, is faced with cost variables related to materials, direct labor, indirect labor, tooling, and invested capital (Bralla, 1999). Table 1 shows the summary of the cost estimation.

The direct unit cost of the key chain was about \$0.39/unit. However, the indirect cost, such as management, transportation, and advertisement, also needed to be considered (DeGarmo, Sullivan, Bontadelli, & Wicks, 1997). We supposed that we would get a 5-year contract, which needed to produce 50,000 key chains per year. The indirect cost was set at 20% of the direct cost. Therefore, the total cost (TC) of the product now equaled:

$$TC = (\$0.39 * 50,000) 1.2 = \$23,400.$$

We wanted to achieve a 30% benefit from the total cost. The total price (TP) of each year could be expressed as:

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$$TP = \$23,400 * 1.3 = \$30,420.$$

The price of each key chain (UP) would be:

$$UP = \$30420/50,000 = \$0.61/unit.$$

### Process Planning

The final procedure of the DFM project was to plan the machining processes to fabricate the mold. To optimize the machining processes, the proper machining parameters had to be decided first. A carbide tool was used to cut the mold. Table 2 shows the information of machining parameters and machining sequences.

MasterCam software was applied to create the cutting path and NC program for a CNC milling machine after all parameters were decided. The CAD drawing was directly imported into MasterCam to generate the cutting path. The machining parameters shown in Table 2 were used for each operation. The verification function helped us to evaluate whether the cutting path generated was proper or not. After the cutting path was decided, the NC program was obtained and then used in the CNC machine to cut the injection mold. Thus, the project was prototyped and evaluated throughout this process.

### Conclusions

Although design and manufacturing generally are two different departments, the development of a DFM curriculum provides the opportunity to integrate design and manufacturing. This module was created to help students to learn how to design a product from its concept to a realization of the actual part, what to look for in the design, what type of material to use, how to estimate the overall cost of the final part, and how to produce it. For students who graduate from an IT department, it is very important for them to understand how to integrate the courses they have completed. The DFM curriculum provides the students the knowledge necessary to communicate valuable ideas to the design engineer. It also provides an opportunity for them to understand how to apply their knowledge in the future in both the design and manufacturing areas.

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## Developing a Technology Management Curriculum from the Perspective of Strategic Intent

Al Bellamy, Pamela Becker, and Paul Kuwik

Universities throughout the country have become increasingly aware of the competitive environment in which they exist. The emergence of such functional units as extended degree learning programs, satellite extensions, online courses, and corporate education programs and a substantial increase in marketing and advertising campaigns attest to this age of competitive enlightenment. Recent and emerging demographic changes in birth rates and age distribution along with the emergence of colleges that utilize nontraditional delivery methods of educational services are capturing the attention of an increasingly limited pool of students, presenting a real threat to institutional homeostasis. Accordingly, institutions of higher education, similar to their private enterprise counterparts, find themselves with the unfamiliar task of *strategically* competing for students. It is imperative that universities understand the authenticity of this competitive environment and the entropic forces that it produces. Similar to the private sector, universities must realize the importance of developing programs and services that will not only sustain institutional integrity but also lead to competitive advantage. As Levine (2000) stated:

The survival of some institutions... will be increasingly threatened by both domestic and foreign for-profit institutions, as well as nonprofit competitors like libraries and museums that also have entered the educational marketplace. Moreover, technologies are encouraging the rise of global universities, which transcend national boundaries. The most successful institutions will be those that can respond quickest and offer a high quality edu-

cation to an international student body. (p. 14)

Many different types of organizations are seeking ways in which to strategically utilize technology as a way to enhance their operational effectiveness and efficiency and to gain competitive advantage. However, there is a paucity of technology management programs within universities and colleges that offer comprehensive instruction on this topic. The absence of such programs represents an opportunity for academic institutions to respond to a significant environmental need through the development of a technology management program.

This article has two primary objectives. The first objective is to provide a basic definition for technology management. There is a lack of common understanding and definition of technology management within the academic community. Technology management is more than just a conglomeration of courses. It has an identified body of knowledge that can be taxonomized and operationally defined. Technology management reflects the need to identify and comprehend radical changes that are occurring at historical, technological, and institutional levels of analyses that few perceive with clarity. We contend that it is precisely the ambiguity inherent within the current informational technology revolution that has created a critical need for programs that clarify, illuminate, and serve as a heuristic guideline for practitioners attempting to navigate their organizations through relatively unknown contours of the information age.

The second objective is to discuss how a viable technology management program can be used as a strategy for

responding to student-client demands for management programs relevant to technology. We will attempt to describe the need to develop programs within the framework of *strategic intent*, a concept developed by Hamel and Prahalad (1993), which emphasizes the importance of systematically integrating strategy and implementation processes to effectively accomplish organizational objectives directed towards obtaining strategic advantage.

### Technology Management Defined

Even though there is empirical evidence that most private and public organizations perceive technology management as something that could help to improve their operations, there is no common or comprehensive interpretation of its meaning found among practitioners and academics (Steele, 1989). Technology management "links engineering, science, and management disciplines to address the planning, development, and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization" (Manufacturing Studies Board, 1986, p. 1). An axial idea inherent within this definition is that technology management is an interdisciplinary field of study. A point to be made here is that the interdisciplinary nature of technology management is more than an academic construct or another cross-functional team approach within management. Rather it is a radically different conceptual and methodological management framework that addresses the critical need to understand the convergence between the idiosyncrasies of an information society and new modes of organization. The industrial era featured vertical and horizontal fragmentation of

tasks and coordination as the primary means of organization. This mode of production represents not only the structure of management practice but consists of the superstructure that permeates institutional, cognitive, and individual action. In short, it became the *industrial paradigm*. This deeply ingrained mindset is a major factor contributing to the inability of individuals to perceive and understand the new integrative principles that are inherent within the information history. This in turn has promoted a fragmented and myopic viewpoint of technology and how it is managed. Steele (1989) stated that there is a

definite need for an integrated view of technology, which in turn treats it as a closely linked system. This system spans the spectrum from creating new knowledge to servicing a product after it is sold. It includes the work to invent and develop products, the processes needed for their manufacture or delivery to customers, and the information processing inherent not only in all of these activities but also in the functioning

of an entire business. Technology pervades all aspects of an enterprise, and effective management must recognize its pervasiveness and its crucial role in establishing competitive advantage and even survival. (p. 6)

This new integrative perspective of both technology and management has been extremely difficult to grasp, not only among practitioners, but also within academia, whose educational structures, in fact, also reflect the orientation of the industrial paradigm. More specifically, academic processes are organized according to highly fragmented fields of study or disciplines. What emerges from this fragmented context is an academic orthodoxy that implicitly describes an approach for creating courses that appear to be addressing environmental directions and needs. The outcome, however, is normally a disjointed and fragmented course program that does not comprehensively satisfy environmental concerns. This is due in large part to the lack of development of an identified body of knowledge. Universities recognizing the need to incorporate some aspect of tech-

nology management into their curriculum, particularly for their technical programs, have traditionally added one or two courses within already existing programs of study. For example, Stanford University added management training to engineering, Massachusetts Institute of Technology has chosen to integrate management and engineering, and Harvard University has chosen to incorporate technical awareness into its management programs (Bahouth, 1994). However, technology management and the knowledge objectives that it addresses are far too complex for this fragmented approach. It is not one or two courses that can be integrated into existing curricula. Rather, technology management is a discipline in and of itself (Ulhoi, 1996) that contains an interdisciplinary body of knowledge, and when considered as a whole, is far greater than the sum of its disciplinary parts.

#### Technical Management vs. Technology Management

It is commonplace for technical departments within colleges or schools of technology to define technology manage-

ment as technical management. However, there is a distinct difference between technology management and technical management. Technology management seeks to:

- Integrate the knowledge of relevant disciplines into one interdisciplinary approach, thus imparting a more comprehensive understanding of the management of technology.
- Develop a macro perspective of the interface between technology, organization, and management.
- Create a broader perspective of technology that goes beyond the boundaries of one's technical orientation.
- Develop technology management skills that are applicable to nonindustrial settings as well as industrial settings.

Technical management, in contrast, is much more narrowly focused within its knowledge base. Its objective is to create an *understanding* of management principles *within* a certain technical area such as engineering or industrial technology. Management topics such as project management would receive considerable attention within technical management. While *technical skills* such as project management would be incorporated within a technology management curriculum, they would be subordinate to its objective of developing cognitive abilities for understanding the new management genome of the information age. This cognitive framework is expressed in Figure 1. This figure describes the need for students to possess an *integrative* understanding of technology and management. More specifically, the wheel circle connects each of the courses and indicates that each of the courses is not an isolated topic of knowledge. Rather, the information that is presented within each course is systematically integrated to the core themes of technology management. This integrative understanding is imperative for managing the paradoxes that exist within the information society. These paradoxes consist of the simultaneous

coordination of:

- Organizational stability and change.
- Quality and work process efficiency.
- Organizational flexibility and standardization of work processes.

These management dichotomies were recognized within the industrial management paradigm as conflicting forces. Within the information age, they are perceived as elements that must be simultaneously integrated in order for an organization to be effective. Indeed, they form the bases for strategic and competitive fecundity (Burgelman, Madique, & Wheelwright, 1995). Technology management concerns itself with the creation of conceptual frameworks that provide instruction on the basic elements of this integrative managerial viewpoint. It further enunciates the ways in which technology can be systematically utilized by organizations as a strategic lever for integrating this dimension into their processes.

Technology management should be approached much more systematically. Systematic program development would include the development of an entire curriculum on this topic and not just a few courses haphazardly scattered throughout the university. Most important, technology management should be thought of as a strategic initiative for the university or schools of technology. We will now direct our attention to this idea.

#### Strategic Intent and Technology Management

It is well recognized that technology management is a vital skill set for the modern manager. Universities are supposed to be the training fields where managers are prepared for future battles (Bahouth, 1994). Currently, however, there is a discrepancy between what organizations require of their managers in terms of this skill and what universities actually offer. This void within the environment should be seen as a strategic opportunity for universities. Strategy refers to how an organization manages its relationship with its environment

(Robey, 1995). Strategic intent relates to creating strategies with the objective of winning (Hamel & Prahalad, 1993). While universities are familiar with strategy making, the idea of directing this activity towards other educational entities with the "intent" to gain competitive advantage is unfamiliar territory.

The most salient idea underlying strategic intent within the context of this article is that it emphasizes the need for universities to devote more than marginal attention and resources to developing their technology management curriculum.

The concept also encompasses an active management process that includes: focusing the organization's attention on the essence of winning, motivating people by communicating the value of the target, leaving room for individual and team contributions, sustaining enthusiasm by providing new operational definitions as circumstances change, and using intent consistently to guide resource allocations. (Hamel & Prahalad, 1993, p. 22)

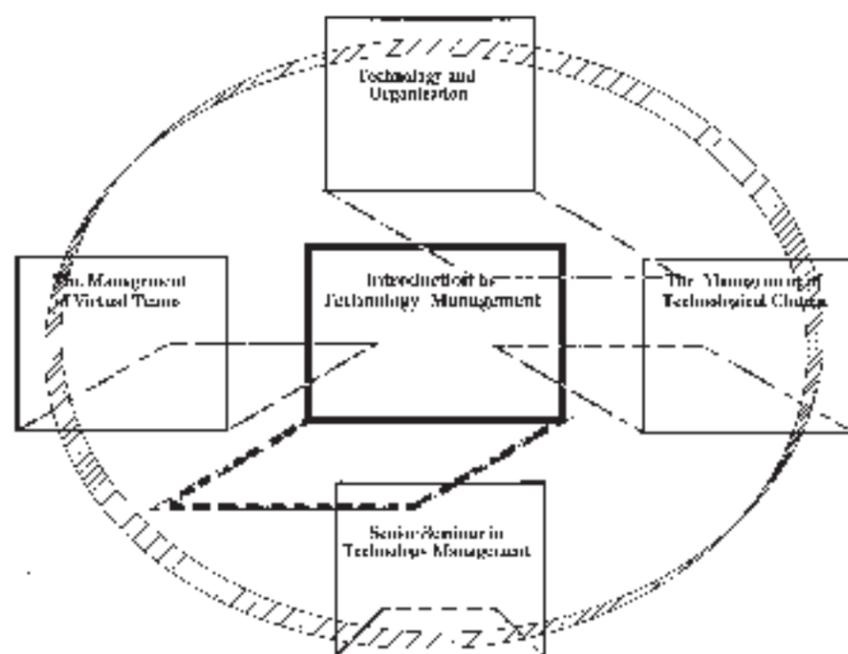
In short, in addition to first recognizing that technology management could be used to ascertain competitive advantage, the key to effective deployment would be to systematically link its strategic intent and its implementation to daily management practices (Mintzberg, 1994; Witcher & Butterworth, 1999).

#### A General Framework for Establishing Strategic Intent for Technology Management

Modern day organizations face a very dynamic environment for which it is imperative to rethink antiquated strategies that were more aligned to stable conditions. In general terms, this environment requires strategies that will deal with the issues of:

- Flexibility
- Innovation
- Product cycle time
- Quality

Figure 1. An integrated technology management curriculum.



**Table 1. Proposed Technology Management Curriculum Core of Courses.**

Course 1 Introduction to Technology Management	Course 2 The Management of Technological Change	Course 3 Technology and Organization	Course 4 The Management of Virtual Teams	Course 5 Senior Seminar in Technology Management
<ul style="list-style-type: none"> <li>• Linking the Environment, Technology, &amp; Mgt.</li> <li>• The Interdisciplinary Structure of Tech. Mgt.</li> <li>• The New Management Paradigm</li> <li>• An Overview of New Manufacturing Technology and Management</li> <li>• An Overview of New Information Technology and Management</li> <li>• Theories of Technology Management</li> </ul>	<ul style="list-style-type: none"> <li>• A Socio-Technical System Approach to Techn. &amp; Organizational Change</li> <li>• Strategic Intent and Technological Change</li> <li>• Technology Planning and Implementation</li> <li>• Human Resource Mgt. and Technological Change</li> <li>• Quality Processes</li> </ul>	<ul style="list-style-type: none"> <li>• Technology and Departmentation</li> <li>• Organizing for Flexibility</li> <li>• The Matrix Organization</li> <li>• The Meta-Business</li> <li>• Platform Teams</li> <li>• Information Tech. and New Org. Designs</li> </ul>	<ul style="list-style-type: none"> <li>• Characteristics of Virtual Teams</li> <li>• Computer Mediated Communication</li> <li>• Electronic Coordination Mechanisms</li> <li>• Analyzing Groupware</li> <li>• Managing Telecommuters</li> <li>• New Supervisory Practices</li> </ul>	<ul style="list-style-type: none"> <li>• The Strategic Management Process</li> <li>• Developing Strategic Intent in Tech. Mgt.</li> <li>• Project Mgt. &amp; Information Technology in Strategy Implementation</li> <li>• Senior Project</li> </ul>

The authors will attempt to establish a conceptual discussion on technology management relative to strategic intent by utilizing these concepts as guidelines.

**Innovation and Quality**

Strategically speaking, the innovation of products and services is intended to create global leadership for an organization among its competitors. The authors strongly believe that a technology management program can create this result for a university if packaged correctly. Quality factors dictate the content of the program. Quality would pertain to the need for creating a program that fully addresses the concerns of the external client while simultaneously maintaining a clear sense of academic integrity. Although courses exist within several disciplines that reflect some dimensions of technology management, a core of classes is needed that more fully represents the integrative nature of technology management.

Table 1 illustrates an example of the type of courses that this core could com-

prise (this core may be utilized at the undergraduate or graduate levels). Taken altogether, these courses emphasize the need to explore technology, management, and organizational change at deeper levels of analyses than traditionally practiced. This is a dimension that is unquestionably missing within many programs, yet is critical for shedding light on the new management paradigms of the information age. The first course within this core, Introduction to Technology Management, sets the conceptual framework for the entire program by attempting to delineate the processes of aligning history, technology, and social organization that is imperative to understanding effective organizational change within the 21st century. It also provides a broad understanding of the impact of new technology on management systems and processes. (For example, what is the impact of new developments in bioengineering on the food industry and what impact does it have on the ability to obtain strategic advantage?)

While various courses are offered in other disciplines that relate to these factors, they exist in isolation. This course brings these ideas together in *one* course with the *specific* intention of integrating them into technology management.

Course 2 describes the structure and processes for systematically planning and implementing technological change. This course integrates micro, intermediate, and macro levels of organizational analyses. Course 3 provides an overview of how to strategically align technology and organizational design. It represents the macro approach to technology management.

This core provides more comprehensive coverage on emerging technological topics such as “virtual teams” (Course 4). This topic is so new that it questions the fecundity of traditional management frameworks and principles currently being taught in colleges of business. It certainly deserves more than the peripheral attention commonly given within management courses.

The primary objective of the final course within this sequence of core classes, Seminar in Technology Management, is to give students the opportunity to integrate the knowledge ascertained within the other four courses. This will be accomplished by using experiential group projects that realistically simulate the integrative management perspective of technology management. Creating linkages between corporations and other organizations with this course will greatly facilitate the realism and learning objectives of these projects. The course will give comprehensive instruction on project management. However, project management is deployed within this class as a technological lever for accomplishing the group projects as opposed to a stand-alone course.

The authors feel that this core balances the need for academic integrity and practical relevance. Equally important is its ability to incorporate both manufacturing and service-type organizations. The majority of technology management programs are directed at the manufacturing/engineering market. The service sector accounts for approximately 70% of the gross national product within the United States, and it also utilizes around 80% of all information technology equipment and software produced (Bahouth, 1994). However, the service sector has been relatively unrecognized within technology management. Approaching the service sector definitely has the potential of affecting strategic advantage (Porter, 1994).

Another salient dimension of quality pertains to the importance of actively interfacing with external organizations for determining their technology management needs. This means that universities will have to take their product *to the market*, which challenges traditional expectations that the market will accept whatever universities produce. As stated by Fawcett, Smith, and Cooper (1997),

firms fail in their quest for competitive success because they too often fail to recognize and understand customers’ real needs—making the identification of appropriate competitive priorities very difficult—and they are unable to focus their efforts and resources on activities that add real and distinctive value. The essence of competitive success can thus be summarized as selecting customer appropriate strategic priorities and then developing the corresponding operational excellence that leads to high levels of customer value. (p. 411)

Although the authors are referencing the private sector, these comments are directly applicable to institutions of higher education. This requires the need to strategically create flexibility within the university’s operating structure and delivery system.

**Flexibility and Product Cycle Time**

Flexibility refers to an organization’s capability of adapting rapidly to the demands of its environment (Cambell, 1998; Upton, 1995). This encompasses the ability to:

1. Produce different services and products simultaneously.
2. Alter the rate in which services and products are produced.
3. Adapt to varying delivery rates of services and products.

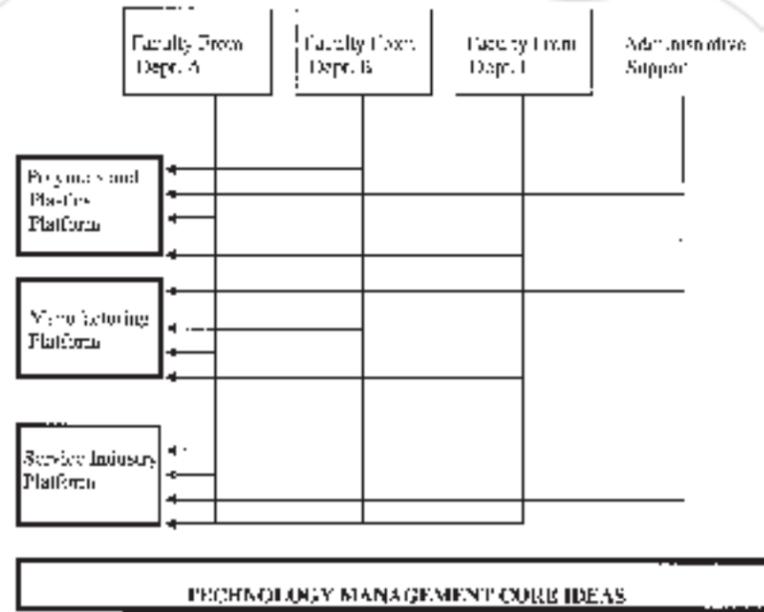
The organization’s structure, processes, and technology primarily affect these dimensions of flexibility. The highly fragmented and specialized structures commonly found within academia are not amenable to establishing the flexibility that is needed to adapt the technology management core (and electives) to the specific demands of varying clientele. Furthermore, it does not facilitate the reduction of cycle time, which is clearly a strategic factor. Product cycle time refers to the time it takes to design a product or service, test it, and deliver it

to the market or client. These concepts as they apply to academia relate to developing and delivering new programs. Fragmentation of structure also undermines this capability. The problem is accentuated by course adoption policies, organizational culture, and political battles commonly found among academic disciplines involving the protection of subject domain.

Establishing strategic intent for a technology management program would involve radical changes within academic structures in order to create processes that would lead to flexibility. This would require the development of true interdisciplinary structures that would integrate relevant knowledge and processes and reduce the time for program development and delivery. Using private industry as an example, Chrysler’s platform team structure, which consists of individuals representing all the relevant functions for designing, prototyping, and manufacturing a line of automobiles, has enabled the corporation to secure competitive power through innovative design and the reduction of product design cycles (Kisiel, 1998; Lutz, 1994). Universities can accomplish similar outcomes with a technology management program by developing interdisciplinary platforms consisting of both faculty and support functions from relevant disciplines and administrative groups within the college and/or university aimed specifically towards identified client needs. This would allow the university to take better advantage of its “core competency” (Hamel & Prahalad, 1994) of diversified knowledge which in and of itself can be considered a strategic factor.

Figure 2 presents a hypothetical example of a platform team structure that is based on the objective of developing market-oriented technology management programs within the College of Technology at Eastern Michigan University. Three development platforms are illustrated: polymers and coatings, manufacturing, and service industries.

**Figure 2. Model of a technology management platform structure.**



Each platform would consist of faculty from relevant departments within the College of Technology who would be responsible for:

- Market analyses of the type of technology management programs that organizations within each sector are requesting.
- Utilizing the technology management core of classes as an organizing framework, develop customized technology management programs based upon specified organizational needs.
- Developing the administrative processes

necessary to support the developed programs.

We recognize that there are a large number of administrative tasks and obstacles that must be systematically planned for in order to operationalize this type of structure. We don't have the space in this current article to discuss these matters. Our intent is to postulate a possible academic structure that would have the capability of supporting the dynamic processes cited within our framework of strategic intent.

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**Concluding Remarks**

The ideas presented within this article are only intended to alert academic planners of the possible competitive benefits of raising their technology management programs to the strategic level. This will require systematic research on the ways in which other institutions are approaching this subject in order to accurately formulate a technology management strategy and objectives (Hitt, Tyler, Hardee, & Park, 1995). Universities have commonly focused on the advertising dollars spent by other educational institutions and have adjusted their advertising budgets accordingly. However, this is not a complete definition of competition. In other words, competing refers to competing for the future by creating innovative services and products that exceed those of the competitors. Technology management represents such a product.

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**The Challenges in Teaching About Intelligent Building Technology**

**Joachim Dittich and Ludger Deitmer**

*This article is based on a paper entitled "Bridging the Gap—Experiences and a Concept in Technology Education, Networks, and Regional Innovation in the Field of Intelligent Building Technology" presented at the International Conference of Scholars on Technology Education at the Technical University of Braunschweig, Germany, September 24-27, 2000.*

**Automation Technologies in Buildings—Benefits and Opportunities**

The term automation technologies in buildings, or building automation (BA), refers to a continuum of applications involving buildings, information, and automation technologies implemented in buildings. This article starts with commercially used buildings, where the technologies are implemented for the following purposes: to reduce operating costs in terms of resource consumption; to centralize control of lighting, heating, ventilation, air conditioning, and the like; to conform with supplier contracts in terms of peak energy consumption; to ensure reliable operation of the systems; and to meet security needs with respect to operating hazards, break-in, fire, or flooding. It also discusses private homes, where comfort, security issues, probable energy savings, and the integration of alternative energies are matters of concern.

As indicated, modern information and automation technologies can con-

tribute to the reduction of personnel costs to run a building, enhance the operational security of buildings, increase comfort, and ensure that limits on conditions such as temperature, air quality, and peak energy consumption are met. To a certain extent, modern information and automation technologies can also contribute to reducing the consumption of natural resources such as fresh water and energy by switching off lights when no one is in the room, by reducing energy input through solar radiation, and by coordinating heating, ventilation, and air conditioning systems. (In the building we work in, for example, we identified energy savings of around 30% for lighting thanks to automation using brightness sensors and motion detectors.)

Recent developments in the construction sector, namely the statutory restrictions (at least in Germany) of energy consumption for heating, have led to the emergence of so-called low energy buildings. Very little heat is lost through the enclosure, which is beneficial in win-

ter. In summer, however, solar radiation penetrates the building through the windows, heating it up and making it necessary to provide for cooling since there is no heat transfer through the walls at night. Ventilation systems have to be installed because the impervious enclosure does not permit natural air exchange. Renewable energy sources are used to provide the small amount of energy needed for such things as hot water. However, solar energy is also used for heating and cooling (e.g., by means of adsorption machines). All these processes have to be coordinated. Photovoltaic systems produce electrical energy in a decentralized manner on the roofs of buildings, thus helping to avoid the use of nuclear or fossil fuel to operate power stations. They have to be coupled to the power net in terms of frequency and phase, and there must be a data capture system installed. Automation technology is frequently required to perform these functions in addition to the above-mentioned heat management. In these cases, some tasks cannot be performed by people because they would put too heavy a burden

on the user; other tasks are carried out through automation for greater overall convenience.

These are the benefits, along with the necessities, of introducing automation technologies in buildings. Now we come to the opportunities. Instead of a lengthy discussion of added value concerning rental or sale, we wish to focus on regional markets, regional development, and employment. In these areas, BA technologies have the potential to supersede traditional electrical installations. The latter are normally supplied by regional small- and medium-sized enterprises (SMEs), at least in small- and medium-scale projects. But BA still is the domain of industrial suppliers, since work tends to be expensive and is therefore often subject to rationalization efforts. As we know from the construction sector as well as from process industries, calls for tender are published nationwide or even throughout Europe, thus removing economic potential from regional markets. If BA competencies existed at the regional level and if there were BA networks providing all the necessary services from planning and installation to operation and maintenance, a large share of the economic activities could be retained in the region. This could stabilize employment in the electrical trades, which nowadays suffer from declining orders as well as from falling prices in the construction sector (Deitmer, 1992).

Additional opportunities include: The competencies needed and acquired in the BA sector, which are of a systemic nature, may help to increase innovation potential in the building trades by demanding systematic and abstract learning processes and also by crossing the boundaries between trades. The competencies acquired and the structures generated in BA can support Agenda 21 processes (United Nations, 1999) because they require the same type of competencies and interactions between the actors to achieve extensive results. In public

buildings and residential housing, energy conservation and reduction of CO<sub>2</sub> necessitate both a systemic view along with concerted action in building and housing projects that roughly account for 30% of the energy consumption<sup>1</sup> in Germany.

### Obstacles to Technology Implementation

Several facts and attitudes have hindered development in BA applications. Some of them are described here to provide a clearer view of the concept presented in the following sections of this article.

Even managers of major providers of BA systems admit that the development of BA components and systems has not been sufficiently targeted to customer needs (Schneider, 2000). The same often applies to the planning and implementation processes that are insufficiently adapted to end-user requirements (Dittrich & Ritzenhoff, 2000). Further reasons for the stagnation of the market are seen in high prices, few benefits for the customer, an almost exclusively vendor-driven market, few service providers, and, hence, little competition in developing services. Schneider (2000) stated that now the time has come for a rapid development of BA markets: Users are well acquainted with information technologies; producers, vendors, and service providers have discovered the customer; the technologies can now provide surplus value by integrating various technical services; and the opening of the energy market brings in additional players (the energy industry), resulting in augmented competition in the BA service market and thus higher quality and lower prices.

But there is another reason that keeps small enterprises, such as craft trade businesses, away from the BA market. As we learned from several discussions with SMEs, there is a certain disinclination on the part of SMEs towards cooperation with large industrial

firms, which still dominate the market of BA applications and installations. Independence being one of the key values in the craft trade, small firms are afraid of becoming dependent on the large global players. As a consequence, there is little cooperation between large companies and the craft trades. Small firms are rarely engaged in carrying out large-scale BA projects,<sup>2</sup> a significant number of which are carried out for large commercial facilities, so the small enterprises are unable to gain experience and know-how in this sector. Therefore, it is difficult for them to become familiar with the technologies in order to offer them in smaller scale projects, such as for private homes or small commercial buildings. However, small firms could be competitive because of their proximity to the end user along with the lack of interest of large companies in small orders.

The same pattern applies to architects and technical planners involved in standard, smaller sized buildings. Because of lack of experience with the new technologies, they tend to advise their customers to order the proven, traditional technologies in the knowledge that they are less expensive and because they cannot assess the potential added value provided by modern automation technologies. Insufficient experiences might also cause uncertainty concerning guarantee issues as well as potential future customer satisfaction. In addition, it is still difficult, even for experts in the field, to give advice on a specific system that must also meet future requirements, be it European Installation Bus (EIB), Building Automation Control Network (BACnet), Local Operating Network (LON), European Home System Bus (EHS), or one of the DDC solutions.<sup>3</sup> The “convergence” initiative, which brings EIB, BACnet, and EHS together (Penczynski, 2000), the Process Field Bus (PROFIBUS) standard, which has been adopted by the majority of DDC manufacturers, as well as the new ISO 16484-5

standard (International Organization for Standardization, 2003), will most likely defuse part of this problem. Furthermore, there is little knowledge on the issue of amortization of investment in the new technologies. The key issue, however, is that in the past, planners in the sector comprising small buildings seldom advised their customers to buy and use modern BA technologies;<sup>4</sup> as far as we know, the same conditions exist today.

Another obstacle is the manner in which innovation and learning take place in the craft trades, especially in the construction sector. Here learning is incremental, linear, reactive, and by no means theory driven, as pointed out by Gann (1996) or specifically for the German situation by Brüggemann and Riehle (1996). This topic is discussed in detail in the following section.

### Networking and Reflexive Innovation in and for Technology Education in Building Technology

Installation engineering is carried out after the innovation process itself takes place elsewhere. Innovations are implemented by the system developers of the building technology vendors (new supply technologies and new building management system [BMS] and building control system [BCS] products). Innovation is therefore disseminated following a linear model. Small enterprises in the electrical and the heating and plumbing trades have a more or less reactive role in the production chain. They receive much less formal technology training and education than the supplying system industry. They are organized in small workshops with little planning capacity and strong informal learning attitudes. Many new scientific and engineering methods have not yet diffused across the entire sector. Know-how continues to be transmitted through methods of apprenticeship, on-the-job peer group learning, or the study of examples found in existing buildings.

Besides formal initial vocational training, the learning opportunities are very limited because of learning through practice. This “learning by doing” can be described as a process of repetition and continuous improvement on the job at the building site. Knowing that construction is a project-based activity, which produces the previously mentioned products—which are individual and hardly standardized, firms build their competencies on the provision of specialized and often quite narrow skills<sup>5</sup> and on resources that rely on expertise accumulated over many years.

Learning at the workplace and in the organization is therefore usually informal with many breaks and little feedback in the highly complex construction business process. Tasks often vary from project to project, and the site environment does not correspond to that in factories; examples include the seasonal nature of the work and building regulations that vary by region. The use of information technology in buildings (intelligent buildings) makes it clear that this systemic technological concept conflicts with professionalization, codes of practice, and the traditional craft trade demarcation lines upheld by trade unions and employees. On the one hand, we have an all-encompassing systemic technology that integrates all craft trades and on the other we have a “locked system” (Nam & Tantom, 1988), which has severe difficulties in coping with radical technical changes in construction. Traditional approaches to the transfer of know-how assume linear continuity of learning with minor changes and adaptations. However, continuity and linear models of technology education in vocational education and training (VET) institutions and in companies are called into question when radical changes occur, as was experienced with the need to install digital microelectronic technologies in buildings during the 1980s (Deitmer, Ritzenhoff, & Sproten, 1998). New competencies are required to exploit such technological opportunities. But construction firms in the craft trades are unable to respond by means of tradi-

tional, informal processes of innovation. The companies in the electronics and telecommunications sector have to move into the construction arena to fill the gap and, as argued here, in close cooperation and collaboration with the traditional construction firms. A networked approach is needed to strengthen both informal and formal processes of change and learning. Changes occur very frequently at interfaces between the specific craft trades. Therefore, a narrowing to a particular sector (such as solely for electricians) might be a mistake. Greater fluidity in the transfer of know-how between one business process activity and another is required.

Organizational changes have to be looked at and learned because many of the important innovations developed in the construction sector have taken place in organization rather than in technology (fast-track construction process management techniques, overlapping design and construction phases, and learning for each actor involved in the building construction process). Despite competition, the role and function of cooperation is found in the modern construction industry, especially in building up a learning culture facing new challenges of the market. This necessitates a re-consideration of companies as learning institutions (Lundvall & Borrás, 1998). Craft trade institutions have to view themselves as learning organizations characterized by a capability of systemic reflexive learning. This refers to the ability of the company employees to reflect on core values of the organization and operate on the basis of cybernetic thinking and an organizational paradigm changing hierarchy to heterogeneity, which can provide multiple skills and experiences to cope with a problem. Such innovative learning behavior has to be enhanced by an innovative production cluster (Porter, 1990). These clusters encompass building users/investors, architects, technology planners and engineers, and system developers and providers, from software houses to technology component firms, construction companies, craft trade companies and their associated organizations such as chambers and craft trade guilds, regional R&D institutes, higher

educational institutions such as polytechnics and universities that educate building engineers, and—last but not least—the vocational education institutions, both in initial and further training. For this reason an analysis of the production chain<sup>6</sup> is important to understand how technology education and training have to be based and initiated.

The structures described above are based on more hierarchical relationships. The point here is to develop heterogeneous structures in which regional networks act as loosely coupled information and dialogue-based networks. The relationships are based on trust, reciprocity, openness to learning, reliability, and a behavior that is inclusive and empowering rather than exclusive and disempowering. Obviously, these networks have to be moderated and somehow initiated by moderators and promoters. In our example, we argue in favor of the VET institutions, formerly known as competence and demonstration centers, as agents for this.

Regional networks are needed to define the training requirements, based on information from their members. Here we advocate a responsive and more interactive innovation model in which the specific conditions of these small enterprises are taken into account. In this respect qualified training and research institutions face the challenge of assuming their role as regional innovation and know-how centers and act as moderators between large building technology vendors (e.g., Landis & Staefa, Johnson Controls, Honeywell) and the many small enterprises in the installation engineering business. Sectoral innovation centers as part of these networks can furnish colleges with analytical background information on new developments and their energy effects on buildings. For more interactive innovation processes, which are very necessary for the successful implementation of BMS, the regional competence centers must create learning networks and innovative structures with their local companies.

In summary, we pointed out that

companies still have great difficulties with these technologies because they are used to increment change and have problems coping with radical changes as those introduced with these new building technologies. They lack a comprehensive technical learning concept that helps them to adapt their view of their business. Raising awareness through information and demonstration of possibilities, as well as advice-oriented training models, is missing. Vendors offer scattered courses on specific technical problems or even courses on areas such as marketing, but integrative concepts that lead the firms directly out of their traditional learning situation do not exist. A modular training course concept that encompasses all the stages for full establishment of this technology in business is needed. Companies concentrate on the installation of new systems with little attention paid to the provision of services such as maintenance or to integration between design, system installation, and operation. Viewed from the standpoint of an existing craft trade company, the following requirements should be met:

- Determine potential/advantages/ cost benefits of building management services and facilities.
- Provide technical know-how on the new systems from a comprehensive vendor-independent view and thus the ability to combine and develop new skills among the employees in an installation enterprise.
- Establish competency guidelines for these companies in establishing a new service organization.

#### **A Programmatic Concept for Technology Education and Implementation**

Small enterprises, in particular local craft trades, have great difficulties in developing innovation despite the advantages of flat hierarchies and barely formalized communication structures. They suffer from little know-how regarding new building technologies, restrictions in terms of time and finances, and lack of business and market information, which impedes the diversification of products and processes as well as

the necessary adaptation of organizational structures. To overcome the above-described deficits within the construction sector, it is necessary to provide specifically designed programs for technical education and develop cooperative approaches. In northern Germany some of the ideas are conceptualized in several competence and demonstration centers.<sup>7</sup> They are aimed at bridging the gap between technology developers/vendors and users from the construction trades. The central focus of these regional initiatives are network-like partnerships between craft trade enterprises and research and vocational institutions (Deitmer et al., 1995; Ritzenhoff & Deitmer, 1999). These regional initiatives use the support provided by regional, national, and European development and demonstration projects. All these projects<sup>8</sup> deal with specific problems concerning effective utilization of new technologies within buildings. The goals pursued by such projects can be summarized as follows:

- To build up new training infrastructures within selected regions in Europe in order to address know-how deficits and to remove innovation barriers erected by technical and social challenges. Product and process innovations in SMEs rely heavily on organizational and technical conditions and on the competence of managers and employees.
- To provide an environmentally sound technology. Minimizing use of energy and water resources in buildings, for example, should help to protect the environment through reduction of CO<sub>2</sub> emissions.
- To provide perspectives for new employment. The introduction of BCS/BMS systems offers a significant new area of work for the craft trades and for SMEs throughout the European Union. These companies are of particular importance for generating new employment opportunities in regional economies. Monitoring of buildings offers new perspectives in addition to classical installation work. BCS/BMS systems can provide data that may be

analyzed to allow energy management, and these systems are the basis for technical facility management.

- Additional aims include improvements in several aspects of building security, thus enhancing user comfort.

Overall the activities are targeted at enhancing the skill base of SMEs in the installation and engineering sector in three dimensions.

1. The business dimension addresses the following competencies:

- To design, install, and apply technology for customer benefits.
- To handle quality standards for installation and design work.
- To manage the technology based on contractual cooperation with planners, building construction, and other trades.
- To create efficient management services for public and private buildings.
- To assess the potential of buildings concerning the optimal utilization of technology and actively offer advisory services to potential customers.

2. The technical dimension addresses the functional and practical aspects for competent technology design, implementation, and service. Key subjects include the following:

- Sensors and actuators, function, handling, and integration.
- Signal transmission, bus systems, and related tools.
- Management, control, and analysis software.
- BA system setup and control software.
- Technical equipment of buildings, function, handling, and integration.
- Systemic behavior of buildings, including overall and subsystem dynamics.

3. The work-oriented dimension focuses

on work processes going on in craft trade enterprises. The central aim is to enable company personnel to interact with each other, with the customer, and with other trades and also to undertake various work activities to guarantee maximum appropriateness during technology implementation. Learning in the work process is an important issue and should be supported.

The methodological approach to training should be based on the following principles:

- The actual system is always the subject of the learning and innovation process.
- Learning situations are placed at different locations: regional demonstration houses as examples of good practice, regional competence and demonstration centers, and the company itself.
- The learner is instructed in taking planned autonomous action (selecting, applying, and reflecting on information).
- Projects are used to structure learning and teaching processes.
- Cooperative teamwork is supported through supervision and advice.

The tasks of the regional competence and demonstration centers include:

1. The networking of relevant local bodies and SMEs to provide research and development facilities and to encourage cooperative approaches to market development.
2. The provision of business information, cost benefit analyses, case studies on improved environmental benefits, and technical demonstrations.
3. The initiation of further development of technology and systems in direct contact with developers, planners, installers, and end users.
4. The development of new training pro-

grams for skilled workers in close cooperation with the regional actors from the BA field.

5. The development of learning material and concepts for different learning locations (center, work, home, Internet).
6. The provision of consulting services for individual small- and medium-sized enterprises and for consortia of companies in order to install adapted work systems that can perform these new tasks.
7. The provision of detailed marketing information material.
8. Promotion and awareness raising of SMEs, local authorities, and customers through planning and execution of promotional activities (e.g., exhibitions, seminars, regional trade fairs, and conferences in the partner regions).
9. Development of transnational networks (including SMEs) in order to stimulate technology transfer, know-how exchange visits, and cross-fertilization of ideas, including the publication, distribution, and dissemination of project results among European countries and regional enterprise networks.

The aim of the centers is to enable the regional craft trades to develop a new service infrastructure in the building management technology field. The project will encompass the whole range of activities related to the innovation process including human resource development, training, marketing, and the development of innovation centers.

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## Notes

- <sup>1</sup>In 1997 German energy consumption of households amounted to 30%; trade, commerce, and service consumed another 15.8% (BMW, 1999), but not all of it was used for heating, lighting, and ventilation.
- <sup>2</sup>Small electrical companies usually perform the cabling and installation of traditional electric devices as subcontractors, but they are rarely involved in planning and programming a BA system.
- <sup>3</sup>DDC: Direct Digital Control. These are powerful, freely programmable automation units that are available from various manufacturers. A drawback is that they are largely based on proprietary standards and therefore interoperability with systems of other manufacturers may not be ensured.
- <sup>4</sup>The situation is likely to change. Building contractors are beginning to offer pre-planned residential buildings equipped with BA systems and other modern technology, such as solar energy systems.
- <sup>5</sup>Skills are specified in occupational profiles that are centrally defined within the dual German VET system and negotiated between the union and employer organizations. Problems in this connection are discussed in Heidegger and Rauner (1997), that is, the borderlines of these profiles that conflict with market flexibilization and dynamism.
- <sup>6</sup>Analysis of the production chain includes the relationship between producers and suppliers and between producers and users, the role played by the government in setting standards and regulations and sponsoring R&D, and the way in which know-how is acquired through different learning processes.
- <sup>7</sup>Under the auspices of the Institute Technology and Education, University of Bremen, Germany, several centers have been developed. The Center for Building Automation (ZGA), Bremen, based in a VET school, is aimed at supplying the Bremen region with training and advice for regional SMEs to assist them during the introduction of BMS/BCS technologies. They concentrate on initial training in this field. The intention is to provide vendor independent training in a laboratory that provides facilities from different systems providers. The Center for Energy Management in Neumünster shows local enterprises and other institutions how to make use of environmentally sound technologies. Similar processes have taken place in Rostock in the technical training bodies of the Chamber of Craft Trades. All in all a network of different actors from industry (important vendors of this technology), model demonstration houses, craft trades with building management technology experience, and university technical education institutes form a network of different institutions interested in opening up the market through a training, education, and innovation dialogue.
- <sup>8</sup>One example of such a national research project is EcoSol: construction and evaluation of a new solar-optimized office and administration building in Bremen. The demonstration building is evaluated and optimized in terms of energy consumption (Ritzenhoff, Bräuer, Limberg, & Niemeyer, 1998). Transfer activities are conducted in connection with the local building trade as well as building investors, architects, and house users/customers. The project is carried out under the BMBF (Federal Ministry for Education and Research) program in solar architecture (see, for example, <http://www.solarbau.de>).



## To Change Perceptions of Technology Programs

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### Educational Program Quality

The classic definition of quality is “the ability of a product or service to consistently meet or exceed a customer’s expectations.” An important element of the definition, customer’s expectations, requires further defining since customers value certain aspects of a product or service and they therefore associate those aspects with its quality.

Product or service quality has many facets. Quality might include the following elements:

- Performance or the main characteristic of the product or service.
- Aesthetics, which include the “look and feel” of the product or service.
- Special features of the product or service.
- Conformance or how well the product or service aligns with the customer’s expectations.
- Safety, which includes the element of risk of injury or harm.
- Reliability or the ability to consistently deliver the intended results.
- Durability or the useful life of the product or service.
- Reputation of the product or service.

Different customers will have different expectations of a product or service based on the relative value they place on these components at a given moment in time. To make a determination of the quality of an educational program, one must identify the customers and their expectations of the program as they relate to the facets they deem most important. This is particularly true when a program, such as technology education, purports a

significant change in its focus, content, and importance. In essence, the perceived quality of the new program will be influenced by the reputation of the program it has replaced, its academic home, and the faculty associated with the program.

### Perceptions: The Startling Truth (Expressed on a University Campus)

- “I wish you guys would just keep teaching shop” (engineering technology faculty).
- “High schools must have a place to put low performing students” (trade and industry teacher educator).
- “A vital and important part of the university for giving students who don’t succeed in business, engineering, and computer science a second chance” (director of university academic services).
- “Vocational education” (engineering department chair).
- “Occupational training program” (engineering faculty).
- “You don’t have qualified faculty who can teach the newer technologies” (dean of the business college).
- “You are a blue collar college in a white collar university” (university’s alumni organization).
- “The College of Technology is where you go if you don’t know what you want to do” (nontechnology student tour guide).
- “Technology teacher preparation programs don’t care and are nonproductive” (state administrator).
- “Not doing enough to recruit new teachers” (high school technology teacher).
- “Irrelevant” (dean of the college of education).

- “Teacher training programs are becoming increasingly irrelevant” (school district administrator).
- “Without serious scholarship, the unit does not contribute to the mission of the university, except in student credit hour production” (senior administrator of the university).

As I reflected on the comments, I realized that they all had different expectations of what technology programs should do and that these expectations were based on distorted mental images of technology education. I surmised that if I tried to improve the image of my program based on their responses, I would never win them over. In fact, if these indeed were the perceptions of our programs, we had already lost. In his summary of the events that led to the closing of an important technology teacher preparation program, Erikson (1993) said:

Trying to speak objectively, it is not difficult to understand why the department was eliminated. The department had several open lines, the curriculum was outdated, and only a few faculty were involved in scholarly activities that were expected of faculty at the “flagship” campus in the state system. This is a chronology of what happened at Maryland and will continue to happen at other places where faculty do not update curriculum, are not involved in scholarship, and are not unified in their direction. (p. 16)

But, what about the facets of a program they do not know about? Aren’t questions of quality related to past product perceptions and not to what ought to

be? Expectations and statements of quality based on outdated models tend to perpetuate the perceptions and not reality. Is it possible to instill a new image of what technology education is or ought to be?

### Mental Models

Mental models, as described by Senge (1990) in *The Fifth Discipline*, facilitate the organization and integration of complex dynamic events and discrete information into streamlined frameworks. We use mental models to summarize the myriad data and experiences we encounter for retention and rapid access. Limited amounts of information trigger the recognition of a pattern or similarity to other experiences (mental models). Rather than processing and analyzing all of the details of a new event, we make a leap of abstraction that this new event is similar to. We then draw conclusions based on our mental models, and our subsequent actions are based on those conclusions. Mental models are valuable when the assumptions and beliefs they are based on are appropriate and true and detrimental when they are based on false assumptions or the leap of abstraction is incorrect.

The legitimate use of mental models for decision making requires the ability to reflect on our strengths and weaknesses and to know how our experiences have shaped our mental models. This self-understanding is important because our perceptions and eventual actions are based on the mental models we hold. As technology educators, we must always intentionally challenge our mental models and those of our colleagues. Critical reflection and dialogue allow us to expose and correct the assumptions and constraints that our mental models may have assimilated. Critiquing our mental models can lead to decisions that will transform the way we teach, what we teach, and why we teach.

### A Vision of Technology Education As It Ought to Be

A vision is an image of life as it ought to be or how we would like it to be. Reality is how life is. The discrepancy between our vision and reality can be reduced in one of three ways. First, we can compromise the vision: “That’s just a dream, be realistic.” Second, we can distort reality: “It’s not that bad; they just don’t know. We are the university’s best kept secret.” Third, we can progress towards the vision. The first two alternatives are unacceptable. To move from reality to the vision requires a clear understanding of the current situation and a clear description of the vision. We must be brutally honest about the present and eternally optimistic about the future.

The International Technology Education Association’s (ITEA, 2000) definition of technological literacy is “the ability to use, manage, assess, and understand technology” (p. 9). In an exploration of my mental model of technological literacy (Hansen, 2001), I identified three statements that facilitated the process of defining the personal importance of technological literacy and technology teacher preparation:

- Technology can be a powerful tool for helping individuals achieve personal and shared goals.
- Technology ought to alleviate human suffering and promote social justice: to help people “make a difference” in their worlds.
- People must have the knowledge and skills to evaluate and decide on appropriate courses of action when confronted with problems.

A synthesis of these ideas produces the statement that technological literacy is an individual’s ability to adopt, adapt, invent, and evaluate technological solutions to positively affect his or her life, community, and environment.

Technological literacy empowers peo-

ple to live life well and to positively influence their environment. It enables them to not only do what they might not otherwise be able to do but also to become what they might not otherwise be able to become. It is the concept of empowerment that should guide the development and implementation of technological literacy programs. It is individual empowerment that unites the concepts and focuses my passion. Empowered individuals, as it relates to technological literacy, would exhibit several characteristics that clarify the concept.

I believe people who are technologically literate would:

1. *Perceive themselves as capable* of learning about technology to achieve specific objectives and extend their influence in the world, even when confronted with unknown and ambiguous situations.
2. *Exhibit a willingness* to (a) take control of their decisions, (b) invest time and energy in achieving solutions, and (c) take necessary risks to explore divergent options. In short, they would not, nor would they want to, leave these kinds of decisions to others.
3. *Have an adequate knowledge and skill base* to seek, evaluate, and implement technological solutions. They would be able to determine the discrepancy between what they know and what they need to know to achieve appropriate solutions.
4. *Rely on their abilities and knowledge to use technology* to meet personal and shared goals and to make a positive difference in the world.
5. *Reflect* on (a) how and why they use technology as they do, (b) how they and technology interrelate with their surroundings, and (c) the technological strategies they use to achieve their objectives.

Technological literacy fosters (a) self-efficacy, (b) rational decision making, (c) focused knowledge and skills acquisition, (d) critical application, and (e) reflective

practice. This is the model of technological literacy that captures its profound importance. Literacy in technology is much more than the ability to use this or that tool, machine, process, or system. It is the development of human potential and influence through technology. These are the identical characteristics we expect from reading, writing, mathematics, science, and social studies literacy: characteristics that empower success.

### So What?

As technology educators, we must consider the legitimate outcomes of our technological programs. We should be concerned with the results of the future technological decisions of our students and their students. Few of us realize the ubiquitous nature of the technology in our lives. We tend to treat technological progress as if it is a natural law that can be neither managed nor influenced. Yet, as we verbalize this thought, we sense that something is wrong. We intuitively understand that technology can improve human life, and we also know that our technologies can distort and destroy human life. It is our place to ask: What does it mean to live, as humans, in a technologically prolific world and how should this affect the implementation of technology education programs? Naisbitt (1999) elegantly stated:

To love technological progress means that we should cherish it, see its faults and triumphs, heed warning signals, admit mistakes, be open and compassionate, watch, listen, face problems squarely, get philosophical, set standards, question standards, review standards, be informed, and welcome opinions from all professions and denominations. If we love technology we will be careful with it. We won't be reckless. We can enter aware and receptive into a dialogue about technology. We will begin to *nurture* the power of technology instead of rejecting it (as do so-called technophobes)

or blindly embracing it (as do technophiles). (p. 4)

The study of how technology is developed and applied to meet human needs and wants and to drive economic prosperity must *not* be constrained to the techniques of designing, using, and producing artifacts and systems but must include the promotion of the rights of all humans: life, liberty, and the pursuit of happiness. The study of technology must encompass an understanding of technology that goes beyond technical skills and techniques. It ought to be a basic and essential element of a person's general education. In addition to literacy in mathematics, science, reading, and writing, we, as well as our students, must become technologically literate.

### Technological Literacy: A Solution of Global Proportions

As the proliferation of technology continues at unprecedented rates, individuals and societies will be confronted with critical issues as a result of their inability to appropriately adopt, adapt, invent, and evaluate technological solutions to personal, community, and global problems. We are in the midst of a new revolution, the *genome revolution*, which will dramatically affect humankind in unforeseen ways. We not only have the power through this new technology to determine who and what will exist in the future but we can now control the characteristics of future generations. We, and our students, are ill equipped and unprepared to make the kinds of decisions we must make as the genome revolution progresses. Who will prepare the youth of today for the decisions of tomorrow?

The decisions to effect solutions using this technology will be increasingly left to the science and technology experts, those who advise the politicians, since the average person, the technologically illiterate, will be unable to understand the technology. The responsibility and authority to influence the direction and

mechanisms for individual and societal fulfillment will be wielded by an increasingly smaller group of people. Human freedom and action will, as a result, be constrained. The solution to this problem is not the unilateral limitation of technology but the development of a technologically literate citizenry: a citizenry capable of making informed decisions to use technology as a powerful tool for reaching personal and shared goals and for making a positive difference in the world. The success of humanity in the 21st century is contingent on a technologically literate population making sustainable decisions.

One of the functions of a leader is to see what others do not see. Many times we don't know that we should be looking for something. Other times we know we should be looking but don't see what we think we are looking for. Oftentimes we look and see. Other times we look at something so often that we fail to pay attention to it. I suggest that deep within each technology educator is the underlying belief that technological literacy is essential to human development and the pursuit of our most basic and universal human goals and that this belief is the hidden mental model that motivates us. It is this vision that technology education programs must capture and promote. It is this understanding of the importance of technological literacy that ought to guide us in our curriculum development, research, and teaching.

Technology education focuses on innovation. Innovation, though, is often stifled because one becomes fixated on the traditional solutions to problems. Traditions help us transfer our experiences and wisdom from one generation to the next and also help us to not succumb to fads. But, adherence to tradition often leads to traditionalism, which seeks to perpetuate tradition, oftentimes losing the very meaning of the traditions it seeks to protect. We often react to the need for change not by developing new paradigms but by patching up old ones. As much as one desires to be

innovative, the reality is that it is much harder to forget the old ways than it is to create new ways. We must be careful to not let current and past perceptions (mental models) and practices thwart our efforts to develop a technologically literate citizenry.

Now I know why I am in this profession. First, it is because my technology

teachers helped me develop some of the characteristics of technological literacy. Second, future civilizations depend on the essential knowledge and skills we take into the future. I now choose to make a difference, in my current world and for the future, by developing these characteristics in others. Whatever I can do to facilitate the development of these characteristics is, indeed, a worthy and noble

effort. It is a vocation I can commit to with vision, passion, and focus. It is this vision that will guide the development of my technology teacher program.

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## Adaptive Competency Acquisition of Differently Certified Technology Teachers

Patricia G. Coyle-Rogers and George E. Rogers

With the national shortage of technology teachers projected to intensify, the alternative certification of those teachers looms as an increasingly likely option for school administrators (Weston, 1997). Numerous studies have compared the effectiveness of alternative certification programs to traditional certification of teachers. These studies have focused on tangible factors and the background of the participants. But consideration has been limited concerning their readiness to manage the complexities of the technology classroom (Litowitz, 1998).

In an attempt to develop a base of understanding related to alternative certification, Truell (1999) explored levels of concern in career and technical educators. These levels of concern focused on seven categories: human relations, classroom management, instructional activities, personal concerns, work conditions, evaluation, and professional growth. The outcome of his research suggested that concerns by both certification types were task oriented. There was limited discussion related to differences in the essence of teaching, particularly with respect to attributes known as adaptive competencies: intuitive and inductive reasoning, practical skills, and people-oriented tasks.

Various types of alternative certification programs exist. Those noted by Litowitz (1998) include the graduate model, suitable background model, strand licensure model, military career transition model, life experience model, and add-on model. Litowitz also notes that "all of these alternative licensure models can provide the advantage of generating greater numbers of teachers, but some models may have inherent weaknesses in terms of quality teacher preparation" (p. 28). Otuya (1992) indicated that subject matter expertise alone is an inadequate foundation for instruc-

tion because teaching requires the transformation of content into situations that enhance a student's learning. Whiting and Klotz (1999) concurred, noting that alternative certification programs that prepare individuals who currently possess the content knowledge but enter the teaching profession without pedagogical skills are ineffective teachers.

### Purpose and Framework

The purpose of this project was to determine if there are any differences in the adaptive competency acquisition between technology teachers who have completed a school district add-on alternative certification process and technology teachers who have completed a traditional baccalaureate degree certification program. This comparison should provide school district administrators and teacher educators with additional data regarding the effectiveness of this type of alternative certification process in preparing technology education teachers.

This study examines the adaptive competency acquisition of technology teachers certified through the add-on licensure model. The add-on model is an option for teachers who hold a teaching certificate in a discipline other than technology (Litowitz, 1998), who are then provided training related to the technical content of technology. One advantage of this model is that the individuals already have experience related to pedagogical skills and classroom management. However, it is important to examine whether such academic classroom skills can transfer to a technology laboratory environment.

Kolb's (1976) experiential learning theory was used to form the basic tenet of the conceptual framework for this study. This model was chosen because of its usefulness in determining competency acquisition (Laschinger, 1992).

Kolb's view of learning is centered on the assumption that learning does not occur in isolation, but through personal-environmental interactions; these interactions extend beyond formal learning situations into lifelong personal and work experiences (Kolb, 1976; Smith & Kolb, 1986; Ridley, Laschinger, & Goldenberg, 1995). Learning is conceptualized as a cycle that can be summarized through three central concepts: learning styles, adaptive competencies, and environmental press perceptions (Kolb, 1976; Smith & Kolb, 1986). The first area, learning styles, are the means by which an individual processes information. Adaptive competencies, the second area, are the skills required to effectively complete a particular task. The third area, environmental press perceptions, are the learners' views of their competency acquisition. Thus, the acquisition of adaptive competencies served as the conceptual framework of this study.

Adaptive competencies are the skills required to effectively complete a particular task and are the congruencies (balance) between personal skills and task demands (Kolb, 1984; Ridley et al., 1995). These adaptive competencies are accommodative, assimilative, convergent, and divergent.

- *Accommodative adaptive competencies* are the skills required to effectively complete intuitive reasoning tasks, including the following abilities: committing oneself to objectives, influencing and leading others, dealing with people, seeking and exploiting opportunities, and being personally involved.
- *Assimilative adaptive competencies* are the skills required to effectively complete inductive reasoning tasks. They include building conceptual models, designing experiments, organizing information, analyzing quantitative

data, and testing theories and ideas.

- *Convergent adaptive competencies* are the skills required to effectively complete problem solving and practical application tasks, and include the following abilities: making decisions, generating alternate ways to do things, experimenting with new ideas and approaches, choosing the best solution, and setting goals.
- *Divergent adaptive competencies* are skills required to effectively complete people-oriented tasks. They include listening with an open mind, being sensitive to values, imaging implications of situations, and being sensitive to people's feelings (Fry, 1981; Kolb, 1976, 1984; Ridley et al., 1995).

This study explored the following research questions:

1. Is there a significant difference between the accommodative adaptive competencies developed by traditionally certified and alternatively certified technology education teachers as measured by the Adaptive Competency Profile (ACP)?
2. Is there a significant difference between the assimilative adaptive competencies developed by traditionally certified and alternatively certified technology education teachers as measured by the ACP?
3. Is there a significant difference between the convergent adaptive competencies developed by traditionally certified and alternatively certified technology education teachers as measured by the ACP?
4. Is there a significant difference between the divergent adaptive competencies developed by traditionally certified and alternatively certified technology education teachers as measured by the ACP?

Laschinger (1992) assessed student achievement related to competency acquisition in the field of nursing educa-

tion through adaptation of the ACP. The fields of nursing education and technology teacher education share learning components; these shared components are documented in *Elements and Structure for a Model Undergraduate Technology Teacher Education Program* (Henak, 1991) and the *Guide to Undergraduate Education* (National League for Nursing, 1995). Based on a review of these documents, the authors noted similarities between undergraduate nursing and technology education curricula as (a) emphasis on the sciences, (b) interpersonal skills, (c) clinical/field experiences, and (d) preparation for a professional licensure examination.

The ACP is an alternate measure of learning style in which participants rate their achievement level on each of the tool's competency questions, using a 7-point Likert-type scale. The items were generated by Kolb and a panel of experts in the fields of engineering and social work in 1981; they represent specific competencies characteristic of each of the four modes of learning espoused in Kolb's learning theory (Fry, 1981). These items were intended to be generic enough to be useful in describing learning orientations of individuals in a variety of disciplines (Kolb, 1984). In this instance the ACP items were used to calculate a personal profile of adaptive competencies. Mean scores on the four competencies indicate the individual's achievement in that area (Sims, 1983).

To calculate the mean scores for each of the four adaptive competencies, the five ACP items for that competency were tabulated and then this sum was divided by five. This process placed the resulting means back into a Likert-type scale range of 1 to 7, with 1 being unskilled and 7 being highly skilled. Only 20 items of the 34-item ACP assessment tool were calculated; the remaining 14 items serve as distracters. Kolb (1984) reported alpha reliability estimates for the subscales between 0.67 and 0.82.

Based on the common emphasis in the sciences, both nursing education and

technology teacher education programs prepare their graduates with the ability to link scientific knowledge and skill with the interpersonal requirements of the profession. This convergence of intuitive and inductive reasoning, problem-solving abilities, and interpersonal skills form the foundations of clinical reasoning for these professions. This research utilized the ACP that was validated previously in nursing education programs by Coyle-Rogers (2001) and Laschinger (1992) to assess the effectiveness of technology teacher education models, both traditional and alternative.

### Methods Used

Nonprobability sampling was used for this study. The sample consisted of two groups: 5 teachers who had completed a Midwest school district's add-on alternative certification program for technology education and 10 technology teachers with two years or less of experience, who had graduated from the same Midwest state's land-grant university. The district's add-on model consisted of 80 hours of instruction related to the technical content of the technology education field and was conducted by school district personnel.

The ACP and a demographic assessment constituted the mail survey which was sent to members of both groups. The results provided both individual ACP scores and group ACP means from the Likert-type scale responses. For statistical purposes, the ACP subscale means were compared to determine adaptive competency acquisition. Since this research study involved two samples, the *t* test for independent samples was utilized for statistical analysis (Polit & Hungler, 1991).

The response rate was 80% ( $n = 4$ ) for the alternatively certified technology teachers and 60% ( $n = 6$ ) for the traditionally certified teachers. The alternatively certified technology education teachers averaged 50 years of age and were initially certified to teach special education, foreign language, and health science. The traditionally prepared technology teachers averaged 24 years of age

with two years of teaching experience. Seventy-five percent ( $n = 3$ ) of the alternatively certified teachers and 33% ( $n = 2$ ) of the traditionally certified technology teachers were female.

### What We Learned

Overall, the adaptive competency acquisition of the alternatively certified technology teachers was higher than the adaptive competency acquisition of the traditionally certified technology teachers. The acquisition of accommodative adaptive competencies was 6.2 for the alternatively certified teachers and 5.3 for the traditionally prepared teachers. This difference was significantly greater for the alternatively certified teachers when compared to the traditionally prepared technology teachers ( $t = 2.582$ ). Assimilative adaptive competency acquisition was only slightly higher for alternatively certified teachers ( $M = 5.2$ ) than their traditionally prepared counterparts ( $M = 5.1$ ). Both the convergent and divergent adaptive competencies were higher for the alternatively certified sample ( $M = 6.0$ ;  $M = 5.7$ ) than the technology teachers who had completed a university-based traditional program ( $M = 5.4$ ;  $M = 5.5$ ).

Significantly higher accommodative adaptive competency acquisition scores would indicate that these alternatively

certified technology teachers can perform intuitive reasoning tasks more effectively than the traditionally prepared teachers. Higher scores by the alternatively certified teachers in relationship to the acquisition of convergent and divergent skills indicated that these teachers effectively developed problem-solving and practical application tasks as well as people-oriented skills. Similar assimilative adaptive competency acquisition scoring between the two technology teacher groups indicated that inductive reasoning tasks were acquired regardless of the certification program structure.

The result indicating a significantly higher accommodative ACP by the alternatively certified teachers was similar to the finding by Shoho and Martin (1999) who reported significantly lower levels of isolation by alternatively certified teachers. Higher acquisition scores in convergent and divergent tasks support the work of Truell (1999) who also noted that alternatively certified teachers indicated lower levels of human relations concerns than traditionally prepared teachers.

### What It Means

The difference between the two groups was significant in the accommodative adaptive competency ( $t = 2.582$ ). These findings suggest that these

alternatively prepared teachers were able to adapt and successfully manage the environment of the technology education laboratory. However, this difference may be explained by the distinct difference in age and classroom experience between the two samples.

While this study focused on the adaptive competency acquisition, this is only one facet of comparison between the two types of certification of technology education teachers. This study did not examine the technical competency of the alternatively certified technology education teachers. A follow-up study should be conducted to assess whether or not the alternatively certified teachers possess the technical competency to be effective technology education teachers.

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## The 2002 Paul T. Hiser Exemplary Publication Award Recipient

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The Board of Editors of *The Journal of Technology Studies* and the Board of Directors are pleased to announce the recipient of the Paul T. Hiser Exemplary Publication Award for Volume XXVIII, 2002.

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