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The JTS welcomes original manuscripts from scholars worldwide focused on the depth and breadth of technology as practiced and understood past, present, and future. Epsilon Pi Tau, as perhaps the most comprehensive honor society among the technology professions, seeks to provide up-to-date and insightful information to its increasingly diverse membership as well as the broader public. Authors need not be members of the society in order to submit manuscripts for consideration. Contributions from both academics and practitioners are equally welcome.

A general guide to the breadth of topics of potential interest to our readers can be gained by consideration of the 17 subclasses within "Technology" of the classification scheme of the Library of Congress, USA <lcweb.loc.gov/catdir/cpso/lcco/lcco_t.pdf>. This includes engineering and allied disciplines, informatics in its many manifestations, industrial technology, and education in and about technology.

Authors are strongly urged to consult the journal's "Guidelines for Authors," included in this publication, or available at the society's website or provided upon request. It provides additional details on the breadth and nature of topics of interest, the journal's scholarly writing standards, submission guidelines, and review and publication processes.

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Editor's Pages

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.

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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 CAE CAPP	MRP MRPII	LAN WAN Shared DB CIM	NC/CNC CAI/T/T FMS/FAS 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 prespecified 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 flexibility 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 (McClenahen, 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 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 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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Roger Turner is an industrial technology student in the Department of Technology at Southern Illinois University, Carbondale.

References

Ariss, S. S., Raghunathan, T. S., & Kunnathar, A. (2000). Factors affecting the adoption of advanced manufacturing technology in small firms. S.A.M. *Advanced Management Journal*, *65*(2), 14-23.

Bessant, J., & Haywood, B. (1988). Islands, archipelagos and continents: Progress on the road to computer-integrated manufacturing. *Research Policy*, *17*, 349-362.

Brandt, J. R. (1998, November 2). Beyond the supply chain. *Industry Week*, *247*, 6-10.

Ghani, A. K., & Jayabalan, V. (2000). Advanced manufacturing technology and planned organizational change. *Journal of High Technology Management Research*, *11*(1), 1-18.

Goetsch, D. L. (1990). *Advanced manufacturing technology*. New York: Delmar.

Hottenstein, M. P., & Casey, M. S. (1997). Facilitation of advanced manufacturing technology: Implementation and transfer. *Industrial Management*, *39*(5), 5.

Industry Canada. (2002, June 13). *What is AMT?* Retrieved August 8, 2002, from http://strategis.ic.gc.ca/sc_indps/sam/engdoc/sam_hpg.html

McClenahen, J. S. (2000). Connecting with the future. *Industry Week*, *249*, 44-50.

Noori, H. (1997). Implementing advanced manufacturing technology: The perspective of a newly industrialized country. *Journal of High Technology Management Research*, *8*(1), 20-28.

Shepherd, D. A., McDermott, C., & Stock, G. N. (2000). Advanced manufacturing technology: Does more radicalness mean more perceived benefits? *Journal of High Technology Management Research, 11*(1), 15.

Sun, H. (2000). Current and future patterns of using advanced manufacturing technologies. *Technovation, The International Journal of Technological Innovation and Entrepreneurship*, *20*(11), 631-641.

U.S. Bureau of Labor Statistics. (2001). *Hourly compensation costs for production workers: Index U.S. = 100* [Data file]. Retrieved December 10, 2001, from ftp://ftp.bls.gov/pub/special.requests/ForeignLabor/ind2000.txt

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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.[1] 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 battlefront, 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 creates 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 supervisor. 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 (Deeprose, 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 advantage, wrote:

> 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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References

Ahire, S. L., Landeros, R., & Golhar, D. Y. (1995). Total quality management: A literature review and an agenda for future research. *Production and Operations Management*, *4*(3), 277-306.

Allen, C. (1957). Women workers need special handling. *American Machinist*, *101*(17), 123.

Amott, T. L., & Matthaei, J. A. (1991). *Race, gender, and work: A multicultural economic history of women in the United States.* Boston: South End Press.

Baxandall, R., & Gordon, L. (Eds.). (1995). *America's working women: A documentary history, 1600 to present* (2nd ed.). New York: Norton.

Benes, J. J. (1998). 60 years of challenge. *American Machinist*, *142*(8), 29-30.

Berliner, W. M. (1979). *Managerial and supervisory practice: Cases and principles* (7th ed.). Homewood, IL: Irwin.

Burke, S. C., & Goudy, W. (2001, May). *Hispanic/Latino residents by specific origin in Iowa's counties, 1990 and 2000* (Iowa State University Dept. of Sociology Publication No. CS2001-19). Retrieved May 21, 2002, from http://www.soc.iastate.edu/census/2000.html

Carnevale, A. P. (1991). *America and the new economy: How new competitive standards are radically changing American workplaces.* San Francisco: Jossey-Bass.

Child, J., & Partridge, B. (1982). *Lost managers: Supervisors in industry and society.* Cambridge, Great Britain: Cambridge University Press.

Crutchfield, E. B. (1998). How a manufacturing organization selected training as the best means to improve employee performance (Doctoral dissertation, University of Arkansas, 1998). *Dissertation Abstracts International*, *59*, 1865-A.

Dean, P. J. (1995) Examining the practice of human performance technology. *Performance Improvement Quarterly*, *8*(2), 68-94.

Dean, P. J., Dean, M. R., & Rebalsky, R. M. (1996). Employee perceptions of workplace factors that will most improve their performance. *Performance Improvement Quarterly*, *9*(2), 75-89.

Deeprose, D. (1995). *The team coach: Vital new skills for supervisors and managers in a team environment.* New York: American Management Association.

Deming, W. E. (1994). *The new economic for industry, government, education* (2nd ed.). Cambridge: Massachusetts Institute of Technology.

Douglas, C., Jr. (1997). The effects of self-directed work teams (SDWTs) on managerial influence (Doctoral dissertation, The University of Mississippi, 1997). *Dissertation Abstracts International*, *58*, 4342-A.

Drucker, P. F. (1993). *Management: Tasks, responsibilities, practices.* New York: HarperBusiness.

Fair, E. W. (1957). 14 disciplinary problems…and how to solve them. *American Machinist*, *101*(15), 94-95.

Gendell, M., & Siegel, J. S. (1992). Trends in retirement age by sex, 1950–2005. *Monthly Labor Review*, *115*(7), 22-29.

Goetsch, D. L. (1992). *Industrial supervision in the age of high technology.* New York: Macmillan.

Grant, E. L., & Leavenworth, R. S. (1988). *Statistical quality control* (6th ed.). New York: McGraw-Hill.

Grosson, R. J. (Ed.). (1998). Retrospective. *American Machinist*, *142*(12), 98.

Gupta, Y. P., & Ash, D. (1994). Excellence at Rohm and Haas Kentucky: A case study of work-team introduction in manufacturing. *Production and Operations Management*, *3*(3), 186-200.

Hotek, D. R., & White, M. R. (1999). An overview of performance technology. *The Journal of Technology Studies*, *25*(1), 43-50.

Hynds, T. Y. (1997). Transfer of training and self-regulating abilities: A longitudinal field study of manufacturing supervisors (Doctoral dissertation, Purdue University, 1997). *Dissertation Abstracts International*, *58*, 4541-A.

Iowa Governor's Strategic Planning Council. (2000, November). *Iowa 2010: The new face of Iowa* (Final report). Des Moines, IA: Author.

Juran, J. M. (1988). *Juran on planning for quality.* New York: Free Press.

Kerr, S., Hill, K. D., & Broedling, L. (1986). The first level supervisor: Phasing out or here to stay? *Academy of Management Review*, *11*(1), 103-117.

Khol, R., & Mraz, S. J. (Eds.). (1997). Changing face of design engineering. *Machine Design*, *69*(1), 138-162.

Kutcher, R. E. (1991). Outlook 1990 to 2005—new BLS projections: Findings and implications. *Monthly Labor Review*, *114*(11), 5.

Marcus, A. I., & Segal, H. P. (1989). *Technology in America: A brief history.* Fort Worth, TX: Harcourt Brace Jovanovich.

Markert, L. R. (1997). *Contemporary technology: Innovations, issues, and perspectives.* Tinley Park, IL: Goodheart-Willcox.

Markland, R. E., Vickery, S. K., & Davis, R. A. (1998). *Operations management: Concepts in manufacturing and services* (2nd ed.). Cincinnati, OH: South-Western College.

National Industrial Conference Board. (1967). *Managing at the foreman's level* (Studies in personnel policy, No. 205). Oakbrook, IL: Raube.

Parker, W. E., & Kleemeier, R. W. (1951). *Human relations is supervision: Leadership in management.* New York: McGraw-Hill.

Patten, T. H., Jr. (1968). *The foreman: Forgotten man of management.* New York: American Management Association.

Petersen, D. (1989). Three management challenges to high tech manufacturing. *Supervision*, *50*(7), 14-16.

Polakoff, J. C. (1990). The changing role of the production supervisor in the "factory of the future." In D. I. Cleland & B. Bidanda (Eds.), *The automated factory handbook: Technology and management* (pp. 20-34). Blue Ridge Summit, PA: TAB Books.

Redwood, A. (1990). Human resource management in the 1990s. *Business Horizons*, *33*(1), 76.

Rothwell, W. J. (1996). *ASTD models for human performance improvement: Roles, competencies, and outputs.* Alexandria, VA: American Society for Training and Development.

Rue, L. W., & Byars, L. L. (1996). *Supervision: Key link to productivity* (5th ed.). Chicago: Irwin.

Rummler, G. A., & Brache, A. P. (1995). *Improving performance: How to manage the white space on the organization chart* (2nd ed.). San Francisco: Jossey-Bass.

Skinner, W. (1996). Three yards and a cloud of dust: Industrial management at century end. *Production and Operations Management*, *5*(1), 15-24.

Stevenson, W. J. (1999). *Production/operations management* (6th ed.). Boston: Irwin/McGraw-Hill.

Summers, D. C. S. (1997). *Quality*. Upper Saddle River, NJ: Prentice Hall.

Taylor, F. W. (1947). *Scientific management* (3rd ed.). New York: Harper & Row.

Torres, C., & Spiegel, J. (1990). *Self-directed work teams: A primer.* San Diego, CA: University Associates.

Turban, E., McLean, E., & Wetherbe, J. (1996). *Information technology for management: Improving quality and productivity.* New York: Wiley.

U.S. Department of Labor. (1999). *Futurework: Trends and challenges for work in the 21st century* (Labor Day report). Washington, DC: Author.

Volti, R. (2001). *Society and technological change* (4th ed.). New York: Worth.

Walker, C. R., & Guest, R. H. (1952). *The man on the assembly line.* Cambridge, MA: Harvard University Press.

Walker, C. R., Guest, R. H., & Turner, A. N. (1956). *The foreman on the assembly line.* Cambridge, MA: Harvard University Press.

Williams, T. I. (1987). *The history of invention.* New York: Facts on File.

Workforce Resource Bureau. (2001, March). *Barriers to employment: Central Iowa Latino laborforce survey.* Des Moines, IA: Iowa Workforce Development.

Young, L. H. (Ed.). (1983, April 25). The old foreman is on the way out and the new one will be more important. *Business Week* (Special Report), pp. 97-110.

Notes

[1] 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.

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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 discusses 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^3/s - (one $m^3 = 35.32\ ft^3$) 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 underground 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_2)—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^2. The surface area of the reservoir will reach 1,084 km^2, and the land area to be inundated will be 632 km^2—almost twice the original water surface area. The average annual runoff is 451 billion m^3 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^3.

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^3
- Earth-and-rock embankment 31.98 million m^3
- Concrete placing 27. 94 million m^3
- Re-bar 463.0 x 10^3 tons
- Metal works 256.5 x 10^3 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^2). 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^3 per hour, which can satisfy the capability of 550 thousand m^3 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.

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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References

China Yangtze Three Gorges Project Development Corporation. (1999, February). *Three Gorges Project.* Yichang, Hubei Province, China.

China's Three Gorges Dam: Is the "progress" worth the ecological risk? (1996, August). *Popular Science*. Retrieved from http://www.arts.unimelb.edu.au/amu/ucr/student/1996/b.hill/china.htm

Export-Import Bank of the United States. (1996, June 5). *Frequently asked questions about the Three Gorges Dam Project.* New York.

Kosowatz, J. J. (1999, December). Mighty monolith. In *Scientific American: The big and the small.* New York: Engineering News Record.

The Three Gorges Dam Corporation. (1997, November 1). *Some facts about the Three Gorges Project*. Yichang, Hubei Province, China.

Tillou, S. L., & Honda, Y. (1997). *Three Gorges Dam Project, 1997*. Retrieved from http://www.american.edu/ted/THREEDAM.htm

Wahby, W. S. (2000). *China 2000.* Report on a study abroad course in China, May 27-June 10, 2000. Eastern Illinois University, Charleston.

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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 TechnoScience2000+. 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, wheras 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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References

Bajah, S. T. (1999). Science education for development: A case study of Project 2000+ELSSA. *Science Education International*, *10*(3), 13-18.

Bardowell, M. E. (1999). Educational technology in the popularization of science and technology. *CASTME Journal*, *19*(1), 15-23.

Barnes, D. (1976). *From communication to curriculum.* Harmondsworth, Middlesex, UK: Penguin Books.

Coppola, N. W. (1999). Greening the technological curriculum: A model for environmental literacy. *Journal of Technology Studies*, *25*(2), 39-46.

Department of Education and Science/Welsh Office. (1985). *Science 5-16: A statement of policy.* London: Her Majesty's Stationery Office.

Eraut, M. (1994). *Developing professional knowledge and competence.* London: Falmer Press.

Federal Ministry of Education. (1991). *Core curriculum for primary science.* Nigeria: Author.

Growney, C. (2000). The worldwide development of design and technology in the primary school. In R. Kimbell (Ed.), *Design and Technology International Millennium Conference 2000* (pp. 69-72). Wellesbourne, UK: The Design and Technology Association.

Hansen, K. H. (1994). Technology education for all teachers. In K. Boersma, K. Kortland, & J. van Trommel (Eds.), *7th IOSTE Symposium: Science and technology in a demanding society* (pp. 366-375). Enschede, Netherlands: National Institute for Curriculum Development.

Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students' recall of expository text. *Reading Research Quarterly*, *23*(4), 465-483.

Holbrook, J. (1999). Operationalizing scientific and technological literacy—A new approach to science teaching. *Science Education International*, *9*(2), 13-19.

Holbrook, J., & Rannikmäe, M. (1997). *Supplementary teaching materials—Promoting scientific and technological literacy.* Paris: International Council of Associations for Science Education/UNESCO.

ICASE, SEAMEO-RECSAM & UNESCO-PROAP. (2001). *The training of trainers manual for promoting scientific and technological literacy (STL) for all.* Bangkok: International Council of Associations for Science Education, Southeast Asia Ministers of Education Organization; Regional Center for Education in Science and Mathematics and UNESCO Principal Regional Office for Asia and the Pacific.

Jenkins, E. W. (1997). Technological literacy: Concepts and constructs. *Journal of Technology Studies*, *13*(1), 2-5.

Johnsey, R. (1999). An examination of a mode of curriculum delivery in which science is integrated with design and technology in the primary school. In P. Roberts & E. Norman (Eds.), *IDATER 99, International Conference on Design and Technology Educational Research and Curiculum Development* (pp. 115-121). Loughborough, UK: Loughborough University.

Parkinson, E., & Plimmer, D. (1995) *Success with primary technology*. Bradford, UK: Resources for Learning.

Parkinson, E., & Swire-Walton, L. (1997). The Success with Science INSET project for primary teachers in Jamaica: A distance learning initiative to promote scientific and technological literacy. *Science Education International*, *8*(1), 10-13.

Plimmer, D. A. (1996). Applying innovative flexible learning techniques to United Kingdom in-service teacher education. In *Educational technology 2000: A global vision for open and distance learning* (pp. 43-58). Vancouver, Canada: Commonwealth of Learning.

Richardson, J. A., & Turner, A. E. (1999). *A large-scale 'local' evaluation of students' learning experiences using virtual learning environments.* Staffs, UK: Staffordshire University Learning Development Center.

Schank, R. C. (1979). Interestingness: Controlling inferences. *Artificial Intelligence*, *12*, 273-297.

Shimoda, T. A. (1993). The effects of interesting examples and topic familiarity on text comprehension, attention, and reading speed. *Journal of Experimental Education*, *61*(2), 93-103.

UNESCO. (1994). *The Project 2000+ declaration—The way forward.* Paris: Author.

Venville, G., Wallace, J., Rennie, L., & Malone, J. (1999). Building bridges across disciplines: Learning science through technology. *Journal of Design and Technology Education, 4*(1), 40-45.

Yager, R. (1996). *Science/technology/society as reform in science education.* Albany: State University of New York.

Yager, R., & Roy, R. (1993). STS: Most pervasive and most radical of reform approaches to science education. In R. Yager (Ed.), *The science, technology, society movement* (pp. 7-13). Washington, DC: National Science Teachers Association.

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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[1] 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[2] 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)***

Technological sensitivity:	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.
Technological perspective:	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.
Technological confidence:	See technological opportunities, identify technological problems and take on challenges presented by these; question ideas, design and products; etc.
Technological creativity:	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

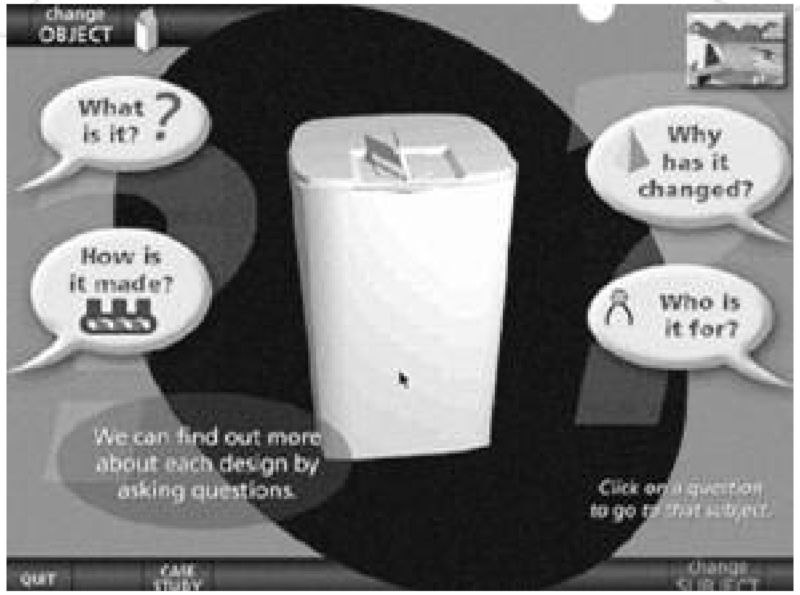
As well as being of interest in their own right, the products explored in the CD-ROM *Exploring Everyday Products: Case Studies of Design & Technology in Action* provide examples of how to use a case study approach. The case studies help to explain how to evaluate products in relation to technology in 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	• Introduction to structures • Pre-planning • Scale (1:10) • Sketch modelling • Group work	Design a structure for 3 campers with belongings and boots
2. Radio	• Awareness of energy sources used in common domestic appliances and machines • Finite versus renewable sources • Sketch design ideas • Annotation • Product evolution over time: style, technology and size	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.

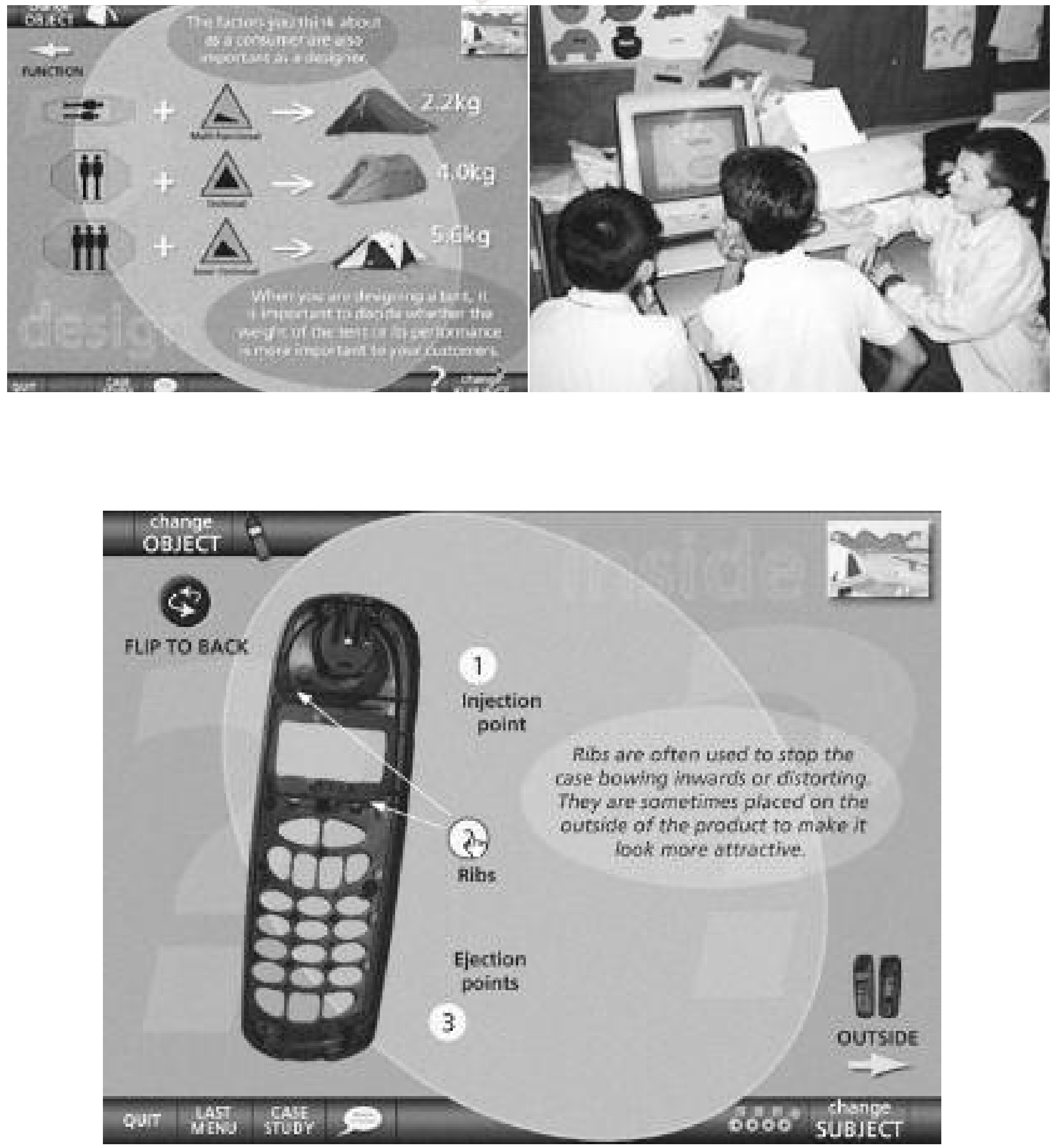
School-Based Trials and Evaluation Responses

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 "argouing [*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 “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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References

Honey, P., & Mumford, A. (1992). *The manual of learning styles.* Maidenhead, England: Honey.

McCormick, R., Murphy, P., & Davidson, M. (1994, April). *Problem solving in design and technology: A case of situated learning?* Paper presented at the annual meeting of the American Education Research Association, New Orleans, LA.

McLaren, S. V. (1997). Value judgments: Evaluating design: A Scottish perspective on global issue. *International Journal of Technology and Design Education, 7*, 259-278.

Scottish Consultative Council on the Curriculum. (1996). Technology education in Scottish schools. Dundee, Scotland: Author.

Scottish Qualifications Authority. (1999). *Higher still design engineering and technology: Graphical communication; technological studies; craft and design.* Edinburgh, Scotland: Author.

Notes

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

[2] 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 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)

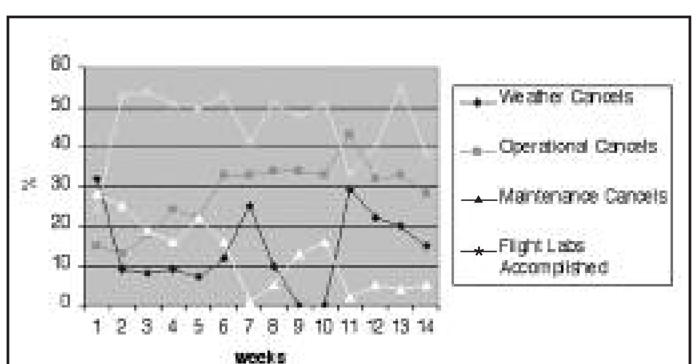


Figure 2. Maintenance costs for A Y00-01.

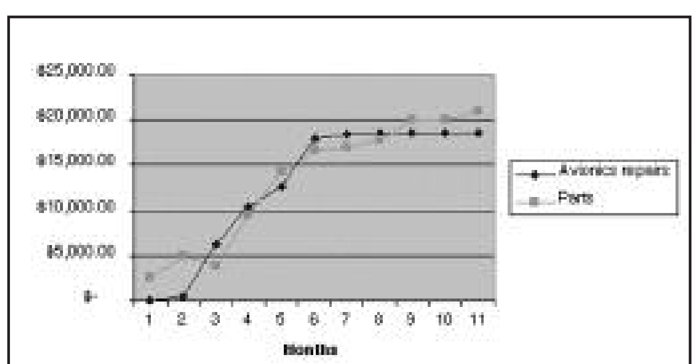


Table 1. Maintenance Activity for Aircraft N5251

Technology Improvement – N345DC	Date	Estimated Cost (then)
Initial aircraft purchase	1980	$80,000
1st Communications and navigation upgrade — basic radios	1982	$7,500
2nd Communications and navigation upgrade — improved radios	1986	$2,500
3rd Communications and navigation upgrade — HIS, basic GPS, DME	1998	$10,000
4th 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 pursue 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

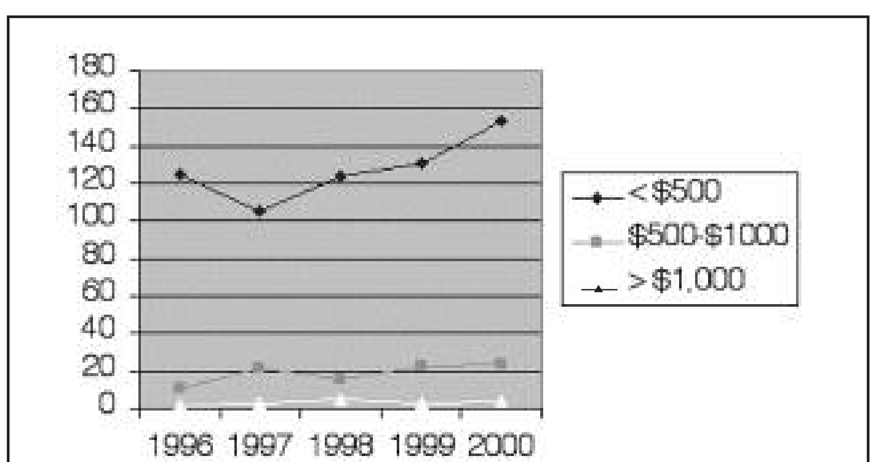
To add further validity to my argument concerning the effectiveness of the timely replacement of aging laboratory equipment, I needed to examine other laboratory-based aviation education programs with similar operations to that of the program at BGSU. After considering several alternatives, I gained 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 particular 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.

Figure 3. Maintenance activity for representive aircraft at Sky King Aviation.



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References

Bowling Green State University. (2000). *Aviation studies budget material*. (Available from Jon McDermott, College of Technology, Bowling Green State University, Bowling Green, Ohio 43403)

Indiana State University. (2001). *Analysis of the Brown Flying Service maintenance data.* (Available from Jon McDermott, College of Technology, Bowling Green State University, Bowling Green, Ohio 43403)

McDermott J. T. (2000). University aviation programs: Using business metrics to validate efficiencies. In *NAIT selected papers 2000* (pp. 137-139). Ann Arbor, MI: National Association of Industrial Technology.

McDermott J. T. (2001). A fiscal model to represent the useful life of laboratory equipment in a university aviation education program. In *NAIT selected papers 2001* (pp. 155-157). Ann Arbor, MI: National Association of Industrial Technology.

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.

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

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

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 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 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.[1] 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, subtasks 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 subject 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 carefully 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 considerable 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:

a. 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.

b. 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.

c. Staff may mark the outcome as a whole and then apply an individual weighting according to their observations of workload or achievement.

d. 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. Hodskinson and Patel (1995), working with engineering undergraduates, considered such peer assessment compares 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 evidence 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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References

Austin, S., Steele, J., Macmillan, S., Kirby, P., & Spence, R. (2001). Mapping the conceptual design activity of interdisciplinary teams. *Design Studies*, *22*(3), 211-232.

Bennett, N., & Cass, A. (1988). The effects of group composition on group interactive processes and pupil understanding. *British Educational Research Journal*, *15*(1), 19-32.

Bradshaw, D. (1989). Higher education, personal qualities and employment: Teamwork. *Oxford Review of Education*, *15*(1), 55-71.

Buchanan, D. A. (1989). *High performance: New boundaries of acceptability in worker control.* In S. L. Sauter, J. J. Hurrell, & C. L. Cooper (Eds.), Job control and worker health (pp. 256-268). London: Wiley.

Cowie, H., & Rudduck, J. (1988). *Cooperative group work: An overview.* London: British Petroleum.

DeBono, E. (1982). *Debono's thinking course.* London: The British Broadcasting Corporation.

Denton, H. G. (1992). *Towards maximising pupil endeavour: An enquiry into a learning approach centred on teamwork and simulation in the context of technology education.* Unpublished doctoral dissertation, Loughborough, United Kingdom.

Denton, H. G. (1997a April). *Developing capability and good practice in team based design work in undergraduate engineering design.* Paper presented at the second conference of the European Academy of Design, Stockholm, Sweden.

Denton, H. G. (1997b). The prior teamwork experience of first year undergraduate designers whilst at school: A focusing survey. In *Proceedings of the International Design and Technology Educational Research Conference* (pp. 28-36). Loughborough, United Kingdom: Loughborough University, Department of Design and Technology.

Denton, H. G. (1998). *Introducing design practice: A novel warm-up exercise for undergraduates.* Paper presented at the Product Design Engineering Conference, Glamorgan, United Kingdom.

Denton, H. G., & Zanker, N. (2000). Design and technology teacher training at Loughborough University: Principles and practice. In W. E. Thauerkauf & G. Graube (Eds.), *Proceedings of the 2000 International Conference of Scholars on Technology Education.* Braunschweig, Germany: Technical University.

Driskell, J. E., Hogan, R., & Salas, E. (1987). Personality and group performance. In C. Hendrick (Ed.), *Group processes and intergroup relations* (pp. 92-105). London: Sage.

Garner, S. (2001). Comparing graphic actions between remote and proximal design teams. *Design Studies*, *22*(1), 365-376.

Ginifer, J. H. (1978). Decision making in task-orientated groups. In R. McAleese (Ed.), *Proceedings of the Conference of the Society for Academic Gaming and Simulation in Education and Training* (pp. 21-29). London: Kogan Page.

Gokhale, A. A. (1995). Collaborative learning enhances critical thinking. *Journal of Technology Education, 7*(1). Retreived from the http://scholar.lib.vt.edu/ejournals/JTE/

Hackman, J. R. (1983). *A normative model of work team effectiveness* (Technical Report No. 2, Research Project on Group Effectiveness: Office of Naval Research, Code 442).

Hodskinson, M., & Patel, R. (1995, July). *More experience with design teams and peer assessment.* Paper presented at the Second National Conference on Product Design, Coventry, United Kingdom.

Hoerr, J. (1989, July). The payoff from teamwork. *Business Week*, pp. 56-62.

Minneman S. L., & Leifer L. J. (1993). Group engineering design practice: The social construction of a technical reality. In N. Roozenburg (Ed.), *Proceedings of the International Conference on Engineering Design* (pp. 301-310). Zurich: Heurista.

Peacock, R. (1989). *An industrialists view.* Paper presented at the second national conference of Design and Technology Educational Research and Curriculum Development, Loughborough, United Kingdom.

Perry, C., & Euler, T. (1988). Simulations as action learning exercises: Implications for conducting and evaluating business and economic simulations. *Simulation/Games for Learning, 18*(3).*pp.*177-187.

Saba, S. (1989, October). The Japanese style of doing business. *Royal Society for the Arts Journal,* 715-722.

Stumpf, S. C., & McDonnell, J. T. (2002). Talking about team framing: Using argumentation to analyze and support experiential learning in early design episodes. *Design Studies, 23*(1), 5-23.

Tuckman, B. W. (1965). Developmental sequence in small groups. *Psychological Bulletin, 63*(6), 384-399.

Notes

[1] 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.

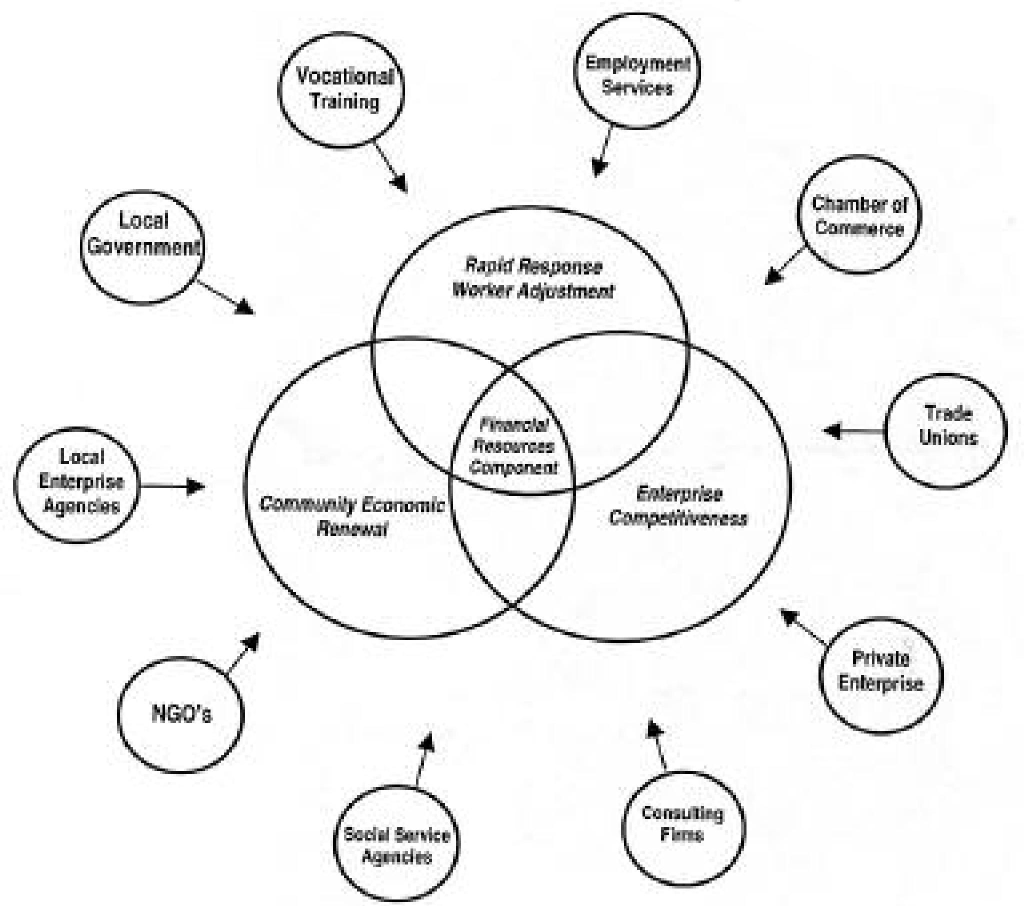
With the fall of the Soviet Union, there has been a need for the development of economic and technical training programs in Central and Eastern Europe. The U.S. Department of Labor (USDOL), through the U.S. Agency for International Development (USAID), has implemented several development projects in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

Hansen, G. (2001). *Use Quick Start training to save or create jobs and improve enterprise competitiveness.* Manuscript submitted for publication.

Herschbach, D. R., & Campbell, C. P. (Eds.). (2000). *Workforce preparation: An international perspective.* Ann Arbor, MI: Prakken.

U.S. Department of Labor. (1998). *Rapid response worker adjustment training manual.* Washington, DC: Author.

Wilson, D. C. (1992). *A strategy of change: Concepts and controversies in the management of change.* New York: Routledge.

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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, drywall 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 questionnaire. 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-

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fessional 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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References

Biddle, B. I., & Ellena, W. J. (1964). *Contemporary research on teacher effectiveness.* New York: Holt, Rinehart & Winston.

DeBarros, A. (1999, October 13). Smaller classes better than money: What top teachers think. *The USA Today*, p. 6D.

Dembicki, M. (1999). Labor department aims to boost the number of apprentices. *Techniques*, *74*(7), 5-6.

Hair, J. F., Jr., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Kindsvatter, R., Wilen, W., & Ishler, M. (1988). *The dynamics of effective teaching*. Whiteplains, NY: Longman.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research. *Education and Psychological Measurements*, *30*, 607-610.

McCaslin, N. L., & Torres, R. M. (1992). Factors underlying agriculture teachers' attitude toward using microcomputers for in-service education. *Journal of Agricultural Education, 33*(3), 45-50.

Medley, D. M., Coker, H., & Soar, R. S. (1984). *Measurement-based evaluation of teacher performance: An empirical approach.* New York: Longman.

Muller, D. J. (1986). *Measuring social attitudes: A handbook for researchers and practitioners.* New York: Teachers College Press.

Nwagwu, E. C. (1998). How community college administrators can improve teaching effectiveness. *Community College Journal of Research and Practice*, *22*(1), 11-20.

Rink, J. E. (1993). *Teaching physical education for learning* (2nd ed.). St. Louis, MO: Mosby-Year Book.

Sikora, D. A. (1997). *Observable teaching effectiveness and personality types of family and consumer science teachers.* Unpublished doctoral dissertation, University of Tennessee, Knoxville.

Tatsuoka, M. M. (1982). Sampling procedures. In *Instructional Monograph* (Serial No. 3). Urbana: University of Illinois at Urbana-Champaign, Department of Vocational Technical Education, Office of Vocational Education Research.

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