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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 Affinscape, 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.

References
Dennis Cheek accepts appointment to executive staff. (2003, Fall). The Epsilon Pi Tau Preceptor, 21(2), 13.
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 now 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 continues to redefine 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 technology? 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 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, 1998). 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, & Kannanath, 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 innovations 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 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 resources, 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. 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, which are 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 continued 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 the 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 computation of this index with the state-of-the-art firm in the industry. When the firm's index deviates from the industry index by a pre-specified value, a signal indicating the need for technological improvement is triggered. The important factors of such an index should include setup time, turn-around time, and minimum lot size as key components. Other considerations should be production flow, flexibility of manufacturing facilities and product line, flexibility of production processes, interdependence of manufacturing segments, and continuity of production. In addition to technical components, the improvements in overall competitiveness and increased market 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 maintenance 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 multiskill workforce cannot be over emphasized. In many instances a reliance on multiskill workforces and the continued commitment to design has allowed many manufacturers to adopt less complex and less expensive manufacturing techniques. A firm's 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 budgetary 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.
4. Project manager/overseer—the person who takes charge of planning.

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 changes 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 MTS. 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 (McClenahan, 2000).

Functional Integration

In addition to facilitating the market or manufacturing interface, the improved process capabilities of an AMT organization can also affect other functional departments of the firm. Of particular relevance to manufacturing is the integration of design and R&D. It has been seen that in the past, the failure to remove organizational barriers between functional areas contributed to integrating too many difficulties that could be 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 the most complete 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 technical 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...
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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 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 (Aris et al., 2000).

References


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 considerably 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 (Aris 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.

Indices

Index U.S. = 100

Table 1: Comparison of Indices

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<th>Description</th>
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<td>Index U.S. = 100</td>
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The Journal of Technology Studies
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. 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, MRPII, SCADM, and TQM (defined later in this article), and they must be technologically literate in them. These complex requirements in the manufacturing technology-job relations 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 (Mackland, 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 simple work rules, 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 (Khal & 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 apprentice- ships 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 to keep 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 selected from the prescribed union list. All disciplinary actions, firings, suspensions, etc., had to follow the letter of the law as interpreted by 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 always 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, & Brodelling, 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 . . . ” (Haxandall & 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 organ- ized 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 (Allan, 1957). Studies by Walker and Guest (1952) and by Walker et al. (1956) uncovered particular human relations skills in the successful supervisor. Their findings showed 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 predominately male to predominately 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 automated 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 product 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 might include a design, 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).

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 tools to perform a single operation, FMS may use computerized machines that can be quickly reprogrammed to do a variety of things, which could be critical in 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; Volf, 2001).

Materials requirements planning (MRP) is a calculation technique that deals with production inventory 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 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, logistic planning, 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 computer-aided 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 before 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, 1989; 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 storage space, 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 improvement 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 respect to the job of supervisor in today’s workforce). 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; Douglas, 1997). However, what is missing from 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 workforce 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 were 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)

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 workforce 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 were 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, noted:...
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 the presence of increased 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 Rummel 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


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

Valleek 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.

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 City, China. More specifically, the TGDP is being constructed in Sandouping Village, Yichang City, China. You can also call it 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
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exceeding that of the largest dam currently in the world (0.6 km), with 12 hydro turbine generator units installed. The total length of the powerhouse on the right is 0.37 mile (518 ft), with 14 sets of 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 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 (CO2)—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 the Great Lakes— 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 km². The surface area of the reservoir will reach 1.084 km², and the land area to be inundated will be 632 km²—almost twice the original water surface area. The average annual runoff is 451 billion m³ 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 m³.

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 investigation of the Three Gorges Dam. 1954 Huge flood; all transportation stopped for 100 days. 1958 Chairman Mao proposes new plan. 1970 Commission 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 finds 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%).

Former U.S. and Canadian support withdrawn. In their campaigns against the dam, International Rivers Network (IRN) and a coalition of US environmental, development, and human rights groups encourage the US 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 Navigation Systems: November 8 End of Phase I, Coferdam 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 by 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
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TGDGP Controversy

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 m³
- Earth-and-rock embankment: 31.98 million m³
- Concrete placing: 27.94 million m³
- Re-bar: 463.0 x 10³ tons
- Metal works: 256.5 x 10³ tons
- Installation of hydro turbine generator: 26 sets (18,200 MW)

TGDGP Cost

In 1990, the cost of the project was estimated at US$12 billion (¥90.09 billion). A more recent estimate is $27 billion (¥223 billion). Perhaps more than any other project in single construction project in history.

TGDGP Quantities of Construction Work

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 TGDGP 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:

TGDGP Advantages

1. Flood Control: The TGDGP 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 TGDGP 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 kilowatt output per year.

3. Navigation Improvement: The TGDGP 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 river, and lower reaches of the river during the dry season and create favorable conditions for the south-to-north water transfer projects.

TGDGP 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 reservoir 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 branch-es 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.

TGDGP Status Highlights

The second of the three construction phases of the TGDGP is already halfway completed. This critical stage presents perhaps the TGDGP’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 basin in 2003. This means breaking every known record for concrete construction (Wabby, 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 presurized 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 Sandozup 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 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 km²). 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 m³ per hour, which can satisfy the capability of 550 thousand m³ per month concrete placing. Each batching plant has its own cooling system that guarantees a 7 °C temperature for cooling concrete in the summer.

- **Diversion works:** Completed; diversion channel opened for navigation on schedule.

- **Temporary ship lock project:** Completed; put into operation on schedule.

- **Ship lift:** Excavation work and concrete placement completed on schedule.

- **Permanent ship lock:** The following were completed on schedule: Surface and underground excavation, excavation work for the lock chambers, concrete placement, underground excavation of the water feed and empty system including inclined shafts and gate shafts, concrete lining.

- **Non-overflow dam sections:** The concrete placement of the left and right bank non-overflow dam sections was started in 1996 and 1997, respectively. Currently, several segments have reached an elevation of 120 m with the left abutment dam sections having reached to the crest elevation of 185 m.

- **Left bank intake dam sections and powerhouse:** Concrete placement of No. 1 to 6 intake dam sections of left bank was started at the end of 1997. No. 1 to 6 units of the left bank powerhouse are planned to be the first batch of generators put into operation. Because of its convenient construction condition, the excavation of the powerhouse for No. 1 to 6 was arranged in the first construction stage and was finished at the end of 1997. The concrete placement was started in January 1998. At the end of 1998, the No. 1 to 5 powerhouse concrete placement of the basement and the tailrace tube were basically finished. The excavation for No. 7 to 14 units was finished by the end of 1998. Concrete placement is in progress.

**Conclusions**

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

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

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

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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, and expand possibilities 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 of population, health, nutrition, environment, and sustainable development at local and global levels (Holbrook & Rannikmae, 1997).

The notion of literacy is seen as a mode of behavior rather than as a literal interpretation of printed information in order to function in social learning settings. 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.
The preceding quote must be seen in context. It is not just about science, but about technology as well. The key 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)

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 is now the 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 resources learning materials entitled "Success with Primary Technology" (Pankinson & Pimm, 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 unified 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 developer writers 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 rights 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" (CASE, 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

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-society continuum (Vagser, 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 (Vagser & Roy, 1993).

The Importance of Contexts

Recognition of the role of contexts is central to the development of TechnoScience2000+. This is achieved at two principal levels. First, industrial workplace-related situational contexts are used as introductory texts. These have a textual narrative delivered by the people directly involved. For example, an industrial safety officer indicates the problems of maintaining a safe working environment, whereas a materials scientist explains new approaches to the use of starch as a biodegradable material for foam packaging. These examples provide a perspective beyond school settings and help to establish the credibility of the resource itself. It is bonded to real people doing real jobs immersed in the research, commercial, and industrial environment 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 the description by Kennedy (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 science 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 & Birair, 1988; Schank, 1979; Shioda, 1993) has suggested that test embracing important life themes and vivid details, especially when written in a narrative form, increases the intensity and effectiveness of the reading experience.
TechnoScience2000+ has been written with this in mind. It has a narrative style and attempt, 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 Erast (1994), which underpins the development of knowledge in the context of real-life classroom situations, supports such a view. Central to the hypothesis of Erast 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 be influenced 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).

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 imbued 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 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


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 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 Environmental Studies, Technology (2000) has technological capability (see Table 1) 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)

<table>
<thead>
<tr>
<th>Technological sensitivity:</th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological perspective:</td>
<td>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.</td>
</tr>
<tr>
<td>Technological confidence:</td>
<td>See technological opportunities, identify technological problems and take on challenges presented by these; question ideas, design and products; etc.</td>
</tr>
<tr>
<td>Technological creativity:</td>
<td>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.</td>
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</tbody>
</table>

Case Studies of Design & Technology in Action

As well as being of interest in their own right, the products explored in the CD-ROM allow 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.

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Table 2. Classroom Trial Activities: Focus and Tasks

<table>
<thead>
<tr>
<th>Activity</th>
<th>Focus</th>
<th>Task</th>
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<tbody>
<tr>
<td>1. Tents</td>
<td>• Introduction to structures</td>
<td>Design a structure for 3 campers with belongings and boots</td>
</tr>
<tr>
<td></td>
<td>• Pre-planning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Scale (1:10)</td>
<td></td>
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<tr>
<td></td>
<td>• Sketch modelling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Group work</td>
<td></td>
</tr>
<tr>
<td>2. Radio</td>
<td>• Awareness of energy sources used in common domestic appliances and machines</td>
<td>Design an everyday appliance or machine which is powered by a renewable energy source</td>
</tr>
<tr>
<td></td>
<td>• Finite versus renewable sources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sketch design ideas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Annotation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Product evolution over time: style, technology and size</td>
<td></td>
</tr>
<tr>
<td>3. Milk</td>
<td>Packaging same job, different product driver for changes over time</td>
<td>Design a milk package for specific target</td>
</tr>
<tr>
<td></td>
<td>color and image association market target role of focus group evaluation</td>
<td></td>
</tr>
</tbody>
</table>

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 product stories. 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 of 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 curriculum 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 need 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 (Mc Cormick, 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 complementarily 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 comprised of three main components: (a) warm up task, to make a down-eling rod stand upright, using only resources found in a box provided for each group; (b) a 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.” The use 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 fingers near [sic] the point of [sic] the glue gun.”
In response to the question, What did you enjoy the least, there were comments such as “arguing [sic] about who does what,” “measuring,” “being quick,” and “being burned by the glue gun.” However, two pupils had liked the CD-ROM the least.

**Task 2. Radio:** This trial started with a discussion about the types of devices, appliances, and machines the children had used from getting up to arriving into school. A wide range of products including alarm clocks, toothbrushes, irons, refrigerators, toasters, bikes, and cars were mentioned. For each product, the children were asked to note the source of the energy that powered the machine/appliance. This was followed by working demonstration circuits of simple energy conversion using visual aids such as a hydro-powered turbine, a steam engine, and engines 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 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 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 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 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 was 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

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 progressive transition between stages of education leading towards qualifications in academic and vocational modules, courses, and group awards at secondary schools and further education colleges.
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
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 deprecate technology equipment as commercial users do, publicly funded technology educators who have struggled to justify the purchase of new laboratory equipment may benefit from a system of quantifiable measurement strategies that capture 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 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).

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 measure 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 technology education program—the costs of new equipment and the expenses associated with it. 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 the 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 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 N52514

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

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

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.

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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 broader 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...
time was spent on social interaction and an experimental setting 21% of project. Spence (2001) estimated that with newly Austin, Steele, MacMillan, Kirby, and teams are better equipped for dealing with unpredictability. It can be argued that however, important in establishing team 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 Spencer (2001) estimated that with newly formed teams of engineers and designers in an experimental setting 21% of project time was spent on social interaction and team maintenance.

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 people 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 multidisciplinary 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 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 brainstorm 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 formal 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-

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. The team 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 one meter square section of wall at chest height using rolled newspaper and thread as structural members (typical 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. This article focuses on Key Stages 3 and 4. In higher education, students are placed in a team with a weaker student or pupils feel they may be disadvantaged if others on teaching practice. One of these examples also apply to students training to teach. 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 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.ldbio.ac.uk/departments/cd.es_dund/prospectus/undergrad_home.htm

Year Four (Postgraduate Certificate in Education)

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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. Gartner (2001) emphasised the importance of sketching as a communication tool for designers and not simply as a recording/design tool. Stumpf and McDonnell (2002) provide 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, norming, and performing" suggested by Tuckman (1985) stages of forming, storming, norming, and performing. New pupils 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, culture. Between these two extremes are 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 pupils with common cultural surnames finding they are placed in teams together.

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 staff needs. Other team-based tasks include designing the most efficient way of assembling identical vehicles made from Lego kits or producing a series of identical paper airplanes (recycle paper). These simulations usually involve a period of team discussion and experimentation followed by a five-minute production run. This is analyzed and the team members are given five minutes for the second iteration and can attempt again. 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, norming, performing. New pupils 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.

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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 background, 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 only in the short term. 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 that staff awareness that when making up teams staff should avoid creating an unsupported minority. An example would be one boy with the girls; better, two boys and two girls.

Small teams are easier for younger pupils, but have the disadvantage that 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 plan warm-up exercises to support 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 simplified projects within 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 indicated above, experience etc., 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 different marks to each individual. Simplicity, 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 monitored can be very valuable training.

c. Staff may mark the outcome as a whole and apply an individual weighting according to their observations of work-load 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 should be equal, but not always.

Staff will have to monitor this carefully. Hodkinson and Patel (1995), working with engineering undergraduates, considered such peer assessment com...


**Notes**

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.

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**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 technical 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.
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 restructurings 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

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Consultant Barriers}

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that affects the success of international projects is using international and domest ic 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 understand, but assist with organizing 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 barri er 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 ben efits 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 bar riers 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 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:

References


International consultants play an important role in the overall facilitation of a project.

International consultants give direction to the project and oversee modifications to the proposed model; their leadership is imperative.

Domestic consultants should be involved to increase articulation at various levels of project organization.

Project sustainability requires articulation with domestic consultants.

The Quick Start model has proven successful in many countries.

Using a model with the components of the USDOL model can promote success within the project.

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

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Selected Factors of Teaching Effectiveness: Perceptions of Apprenticeship Trainers

Howard R. B. Gordon

It is theoretically impossible to measure a teacher’s effectiveness by measuring only student achievement (Biddle & Elmore, 1964; Biddle, Kelley, Coker, & Soar, 1984). There is no scientific method of separating what and how much a pupil learned from the teacher, due to all the other extraneous lists of traits attributed to the teacher (Sinka, 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 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 apprenticeship trainers who comprised the population of the study were operationally defined as prospective trainers of trainees. 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 proportionately stratified sample composed of 46 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 (1988) 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 underlying factors (Hair, Anderson, Tatham, and Black, 1998). Loadings less than .40 were not considered for further analysis. 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, student participation in evaluation, socialize with students, procedures and policies, positive individual attention, communication and feedback, and atmosphere for respect.

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 so; 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, student participation in evaluation, socialize with students, procedures and policies, positive individual attention, communication and feedback, and atmosphere for respect.

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Apprenticeship trainers within the 35 to 44 age bracket 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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