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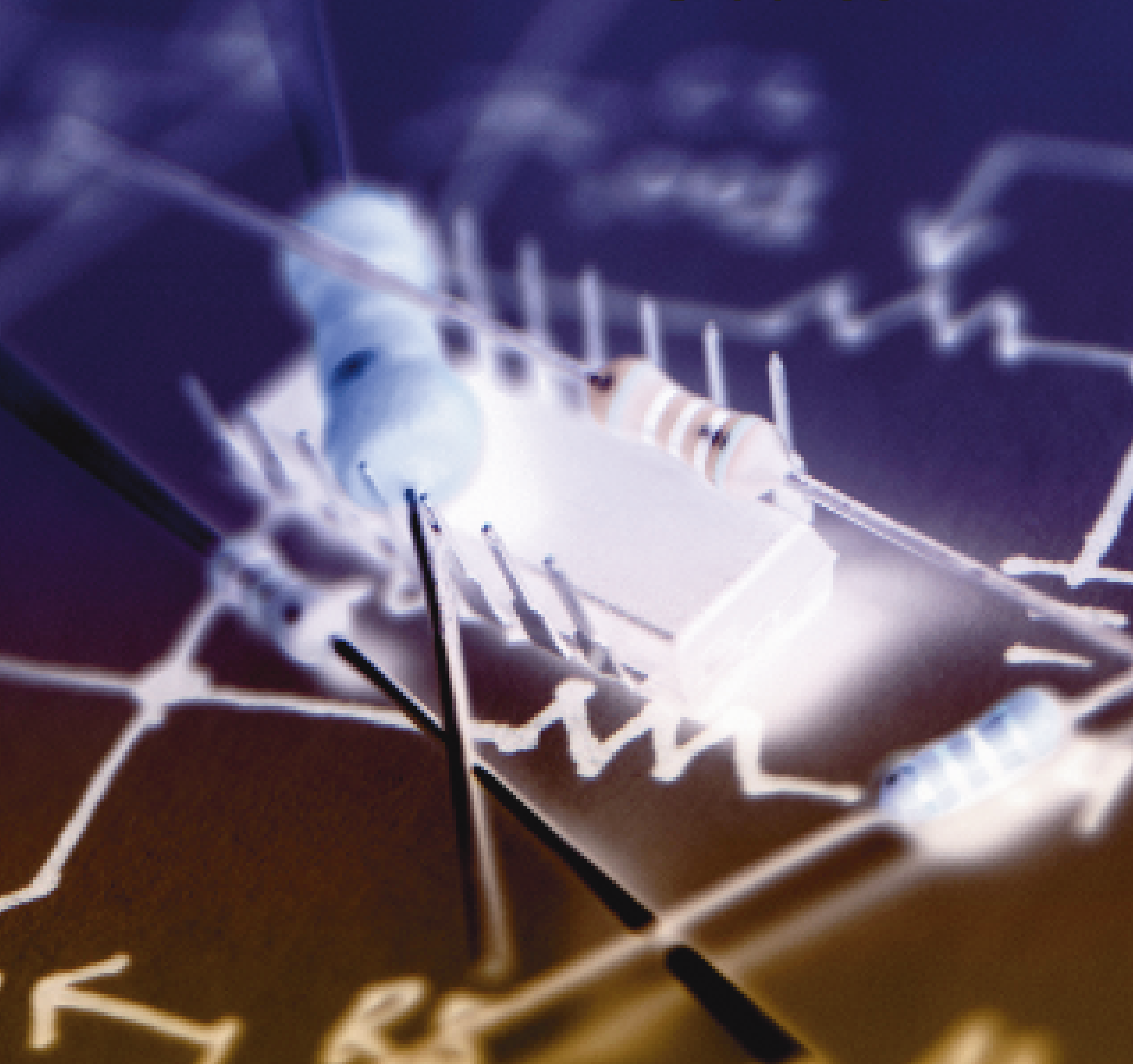

A refereed publication of Epsilon Pi Tau The International Honor Society for Professions in Technology.

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ARTICLES

Designing Technology Education at the Junior High School Level: Propositions from the French School Curriculum

By Lebeaume Joël

Joël Lebeaume is a professor at the École Normale Supérieure of Cachan. His research is focused on technology education from a didactic point of view at the Unity of Research in Scientific and Technology Education (UMR STEF ENS Cachan INRP). He has been a member of the "Technology" working group with the Ministry of Education and has participated in the examination and review of new programs in the area of technology education.

In France, technology is a compulsory school discipline at the junior high school level (ages 11-15). Technology studies were initiated at the beginning of the 1960s when school attendance until the age of 16 became mandatory and when it was decided to delay vocational training because of the irreversible drive towards technical modernity, a tremendous cultural and social upheaval, and a dire shortage of technicians in France. Designing and implementing this new discipline, however, could not happen spontaneously; it required the appropriate tools, in addition to ideas, in order to develop and coalesce the various suggestions, identify likely consequences, and propose a coherent structure. Across the world, technology education systems vary depending upon political, economic, and technical contexts, etc. (de Vries, 1994; Foster, 1997; Zuga, 1997). These differences are also tied to the historical forms of this subject matter, such as industrial arts, design, and arts and crafts, and the relationships held with other disciplines in the educational curriculum. Moreover, they depend upon the philosophical precepts inherent in the definition of the discipline, that is, content-oriented vs. student-oriented.

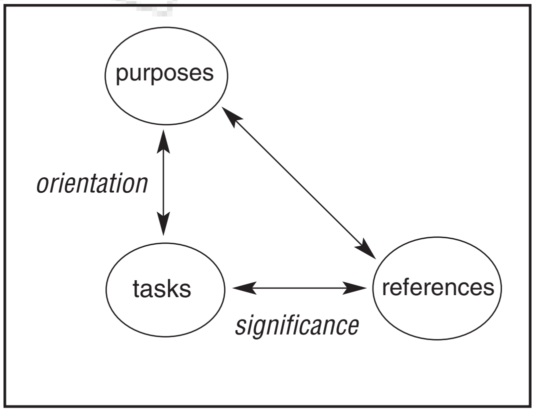
Within the French context, research on the history of this discipline (with a focus on manual work) provides insight into the fundamental issues of its place in the compulsory general school curriculum. Such research has provided the basis for suggesting a number of tools for identifying relevant proposals from recent technology education programs (1996-1998).

This historical inquiry examines two main periods of school organization in France. The first concerns the period 1880 to 1960, during which primary schooling was opened up to the entire population. The second is the period 1960 to 2000, when the school became an educational system and when the junior high school progressively filled the role of middle school. During both periods, the technical world was represented first by means of manual work and then with technological instruction. This historical approach serves to develop a didactic frame of reference specifically regarding prescribed course content and curriculum organization (Lebeaume, 1996, 2000). The two aspects are indeed similar due to the context of compulsory teaching within the general education system.

Manual Work at the Primary School Level

For the past 100 years or so, manual work has been prescribed for boys and girls at the primary school level. The name of this discipline has been modified over the years: manual and experimental work, manual activities, manual educational activities, manual work, handicrafts, etc. These changes are the consequence not only of evolution in the pedagogical conceptions of children and pupils and of their learning, but also in the social roles of men and women. In order to identify the various forms of this discipline, it becomes necessary to characterize the predominant prototypical situations encountered in teaching-learning. A prototypical situation is characterized by the tasks, their significance, and their orientation: What exactly are the pupils doing? And why are they doing it? How do these tasks refer to actual practices? Figure 1 illustrates this coherence in the reciprocal relationships between the three components of this discipline: purposes, references, and tasks.

Figure 1. Representation of prototypical teaching-learning situations: Method.



The diagram in Figure 1 depicts the coherent structure present in each form of the discipline and represents a method, which is to be defined as the special methodology of the discipline. It is necessary to distinguish between the pedagogical and didactic meanings of the methods observed. This distinction does not pertain to the relationships between purposes and means, as do the active methods (pedagogical meaning). According to the didactics perspective, the term *method* draws attention to subject content. It indicates the special methodology behind a school subject, with its features and its specific knowledge. It has been used in the past for music learning, for example, to distinguish between the marked method and the numbered method.

The various forms of manual work at the primary school level are thus: the technical elements method (e.g., series of sewing stitches for girls, or technical elements of woodwork or metalwork), the everyday items method (creation of objects, such as pillowcases, boxes, or tablemats), the geometrical elements method (drawing shapes, folding paper), the amusing things method (toys, dolls, etc.), the logical elements method (graphical representation of threads in braiding, weaving, etc.), and the technical projects method (process of producing technical objects). Each of these methods is represented in the chronological diagram in Figure 2.

The main differences between these historical forms of manual work depend on both the tasks and their references. Some tasks refer to domestic practices, whereas others relate more to workshop activities or industrial jobs and still others to entertainment practices. The significance ascribed to the tasks influences them via systematic exercises or practical activities. Task objectives are also contrasted when it comes to learning technical matters, scientific or mathematical knowledge, understanding the psychological development of children, and discovering the technical world. Without necessarily being aimed at pre-professional training, these purposes were all quite different. Coherence has thus been defined in each of these prototypical situations, as identified respectively by the corresponding methods.

Technology Education at the Middle School Level

The history of technology education since the 1960s also reveals the distinct methods employed at the junior high school level. In the past, it had been organized according to a succession of methods, each featuring special attributes (see Figure 3).

Figure 2. Successive methods throughout the history of manual work in primary schools.

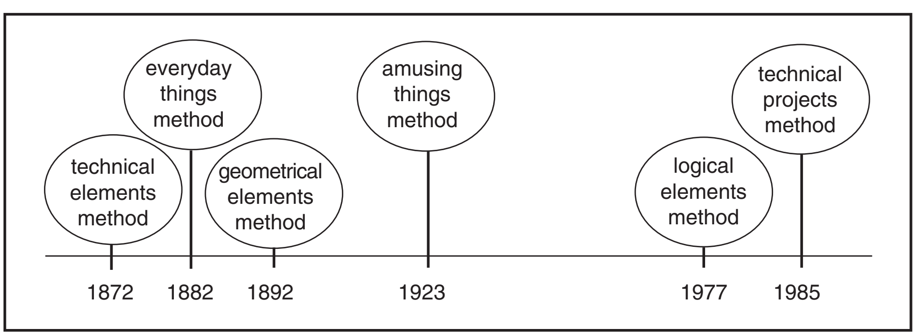
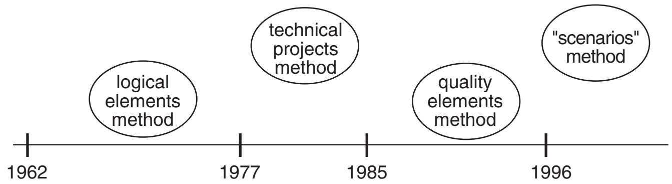


Figure 3. Methods used in the history of technology education for middle schools.



Method	Tasks	References	Purposes
Logical elements	• technical analysis of devices • industrial drawing	• mechanics	• understanding the world of machines
Technical projects	• design and fabrication of technical objects	• domestic and small-scale production	• learning how to do, thinking before making
Quality elements	• use of value analysis tools	• value analysis	• understanding optimization principles
Scenarios	• implementation of technical products	• contemporary firms	• using computers

According to these various forms, technology education may be defined as a component of general education without the goal of being or becoming vocational training. Rather, it is intended as a discovery or initiation to technical practices in order to better cope with and act within the technical environment. Technology education has also been constituted as a requisite school discipline for identifying future jobs and professions.

The successive forms of the discipline at both the primary and middle school levels reveal an alternation in the methods adopted. Two types of methods can be distinguished: syllabic methods and global methods. The first are defined merely by elementary efforts or notions along with the pertinent scientific references, whereas the second are defined by the production of basic objects adapted for the students' comprehension. The first are devoid of any technical significance, whereas the second imply a translation for youngsters of real-world practices as a means of proposing technical educational experiences. This alternation is a sign of the instability of technology education in schools, which often tends to become a series of lessons with a pencil and paper but without authenticity or connection to real-world technical practices.

Main Theoretical Issues

The historical analysis of this school discipline raises three main issues with respect to designing technology education within a compulsory general educational context:

1. How to handle the interactions between knowing and doing in order to design an academic discipline based on reasoning and action.
2. How to harmonize the diversity of technical practices in designing a general school discipline.
3. How to maintain relationships with current social and technical practices so as to provide pupils with genuine interpretations of the technical world they will be required to understand.

These three main issues are fundamental to the design of an elementary, progressive, and general approach towards a whole range of situations combined into a single school discipline under the generic label *technology education.*

Designing the Foundations of Technology Education

The diagram in Figure 1 serves as a base to query the foundations of technology education. Which tasks are appropriate? For which purposes? Which references apply to the set of tasks? The choice regarding references and purposes depends on educational policies aimed at training young people as individuals, citizens, and future members of the workforce. The choice of industrial practices as references is directly linked to the conception of the future from a social and economic standpoint. Is it important to initiate entrepreneurship (Raat, de Vries, & Mottier, 1995), to develop a critical point of view (Deforge, 1993; Petrina, 2000), to promote scien-

Table 1. Comparison of T/M/S Content Standards

Area	# of Stds	Second Level (9-12) Statements	Grade Bands	Date Issued	Web Site
TECH	17 cognitive 3 process	51 cognitive 15 process	K-2 3-5 6-8 9-12	2000	www.iteawww.org
MATH	5 cognitive 5 process	71 cognitive 18 process	PreK-2 3-5 6-8 9-12	1989/2000	www.nctm.org
SCIENCE	7 cognitive 1 process	27 cognitive 2 process	K-4 5-8 9-12	1995	www.nas.org

tific and technical progress, to maintain the technical heritage, to generate new individual or collective skills, etc. Within the French context, history has demonstrated the various choices made over the past 30 years: to enhance the condition of manual workers; to generate enthusiasm for technical jobs; to fulfill the broad-based needs of technicians, marketing professionals, and engineers; to inform customers; etc. The question of why technology education should be included within the compulsory school curriculum is linked to the question regarding references that entails contemporary firms, mass production, workshop activities, etc., as well as to that regarding the choice of fields of technical practice such as mechanics, electronics, economics, and automation (Martinand, 1995).

In relation to the previous choices, the fundamental decision about curriculum would thereby constitute the main type of approach. Would this be a production approach; or an investigation approach of processes and devices; or an analytical approach of quality, objects, and products; or another approach altogether? Depending on the decisions concerning the three method components, a different technology education comes to the fore with a distinct set of contents. The discipline could consist of an experimental technology education, a practical technology education, a design-process technology education, a problem-solving technology education, a creative technology education, and so forth.

In France, the preferred approach has always been to rely upon project-building adapted to the pupils' ages. This decision, however, requires a conceptual framework in order to describe the nature of the school tasks assigned. In technology education, tasks must integrate material of a technical nature, which has been defined from three components (Combarnous, 1984): objects, technical thinking, and specialized roles. Put otherwise, a technical task arises when pupils are confronted with objects (machines, materials, documents, etc.); when they are asked to design, produce, or, more simply, act or carry out as efficiently as possible; and when they play a technical role such as engineer, technician, or technical agent in a context of teamwork. Nevertheless, this project development approach merely involves a few genuine encounters with the technical world without the intention of training project managers or specialized agents.

These encounters with the technical world via a project development approach then serve as a means for interpreting real technical processes and products. School projects enable not only the generating of vital concepts for examining technical reality, such as quality, value, cost, market, organization, and technical standards, but also learning some machine and computer operating skills.

While concrete technical achievements lie at the core of technology education, the use of computers is very closely related therein. Learning how to use computers thoroughly is essential for future generations. Technology education has the obligation of teaching these multiple computer uses (word processing, spreadsheet applications, database management, computer-assisted drawing and manufacturing, communication applications, etc.). One aspect of these programs is centered directly upon the acquisition of such knowledge. This aspect does not fall into the realm of information sciences but rather of information technology, as a result of the technological point of view inherent in this systematic learning approach. However, information technology does not span the domain of the unconscious use of computers. To handle these machines better, practical familiarization does not consist solely of hands-on use but includes reflexive practice as well. Learning is organized by virtue of progressive exercises aimed at understanding how to use computers and how to open, enter, select, locate, save, store, and retrieve files. These capacities must be taught so as to remain with the pupil for future activities and to assist in day-to-day life. Pupils need to know about systems and principles of data processing and assimilate these processes in order to identify the advantages and limitations of data-handling programs or choose from among a set of programs. They also have to build an effective model for dealing with computer-related tasks.

Designing the Organization of Technology Education

Designing the organization of technology education within a general educational context raises two major and interrelated issues: how the program is to be defined within the framework of elementary learning and how its progressive evolution is to be organized. Focus then turns to the schedule of technology education courses during the four-year junior high school curriculum.

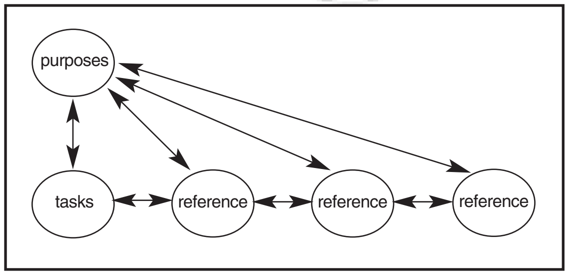
Given that school disciplines are defined simply by a sequence of knowledge acquisition, it is customary to divide the contents into a number of small chunks and then teach them one after the other. Mathematics or grammar lessons, for example, are typically organized around this principle from the simplest to the most complex. In contrast, for technology education (and for that matter for sports and artistic education as well), specific content components cannot be separated into smaller chunks. In the past, this tendency to define technology education as a cumulative discipline distorted its foundations and the school subject got directed towards applied sciences or geometry.

In order to maintain its foundations, technology education must generate prototypical teaching-learning situations from tasks featuring a real technical nature. Defining an elementary school discipline implies choosing technical experiences adapted to the pupils (i.e., enabling them to live a series of adventures shaped by objects, efficiency, and roles). It is also necessary, however, to organize these experiences within a coherent sequence throughout the schooling period.

The history of technology education reveals several principles for determining the progression of the curriculum. The first one consists of repeating the same process in different technical experiences throughout the junior high school program. This principle is at odds with the purpose of technology education by virtue of the tendency of such training to produce project managers. The second principle consists of introducing these school experiences gradually with more open-ended tasks: resources are increasingly scarce, technical projects are increasingly complex, and constraints are increasingly present. This principle corresponds with the definition of technology education as both a school discipline that contributes to developing problem-solving skills and a pedagogical means for nurturing the pupils' psychological skills. The third principle consists of defining just one generic technical area and then progressively introducing new and broader tasks. In the past, the areas of woodworking or metalworking and the realm of mechanical practices constituted these generic references, which provided an overview of the entire array of technical practices. This choice, however, does not comply with the purpose of unspecialized education because of its tendency of becoming more of a vocational training. The fourth principle consists of varying the references from more familiar to more unknown domains, for example, from the home to firms or from domestic practices to industrial practices. This principle is typically applied at the nursery school and primary school levels, where discovery of the world initially proceeds from commonplace tools and familiar objects. The fifth principle consists of proposing different technical experiences encompassing a wide diversity of social and technical references. As an example, the program prescribes technological activities in sewing, cooking, building, electronics, and mechanical assembly. Comparison between these contrasted experiences then enables identifying the consistency of the technical process or tasks along with their technical features. This principle, however, has more to do with planning than with a progressive pace to the instruction. Keep in mind that progressiveness pertains not only to the temporal organization but also to the way in which pupils progress with their learning.

The choice of which principle to employ in setting up a general, elementary, and progressive technology education depends on the purposes inherent in the school discipline. Within the French context, the principle of elementary teaching entails defining project-based accomplishments, whereas the principle of progressiveness implies distinguishing tasks according to the three junior high school degrees. During the first degree, the principle dictates a year of technical initiation in order to acquire basic knowledge of the equipment and techniques, coupled with the implementation of tools in mechanics and electronics and an approach to product marketing. The two years making up the second degree represent a period for gaining technical experience. Each year, pupils are required to experience two contrasted project sequences (to be chosen from among the following: assembly and packaging of a product, mass production after prototype-building, design and building of a prototype, product testing and improvement, diversification of a product range, and service provision). During these project-directed activities, pupils are asked to perform several tasks with references to various types of actual firms or companies (industrial or service). The mass production scenario, for example, proposes different tasks, including the temporal and spatial organization of production, cost calculations, and quality control. During the second year of the middle degree program, the service provision scenario offers new activities: a needs-based study, planning and organization, definition of functional purpose, cost estimation, etc. During the final year of the third degree, pupils are assigned to implement a technical project comprising four main stages: market study, solution search, production, and dissemination.

Figure 4. Differentiation and comparison of different technical experiences.



Throughout the junior high school curriculum, therefore, the principle of progressiveness takes the form of differentiation-comparison (see Figure 4). The first degree provides the basic background of school-based technical activities. The middle degree is centered on the analysis and comparison of technical experiences in the aim of developing a process model. The final degree enables consolidating this general process model and building upon the knowledge and know-how previously acquired.

This progressiveness has been chosen in order to add greater consistency to the school discipline. Technology education is a discipline of experience and not one of content. If the curriculum is defined first by a list of skills, talents, or capabilities, this discipline could be progressively organized around a series of graded exercises, yet the pupils' activities would be insignificant.

In order to comprehend the technological world and act within it, in order to identify relationships between products and human needs, and in order to know how solutions are chosen at different stages of the design process, production cycle, or sales chain in light of technical, human, and economic constraints, technology education focuses on development activities that provide pupils with practical experience and a conceptual framework for describing and analyzing the technical and economic world around them. Such project-oriented activities are then progressively compared and refined by the pupils themselves (Lebeaume & Martinand, 1999).

Designing the Implementation of Technology Education

Thanks to its various features, technology education only exists in the classroom in the presence of teachers and pupils. This truism, however, implies two critical points:

- A program structure in compliance with a standard and a prescription that incorporate the innovation necessary to develop the school discipline and that allow for different types of implementation, depending on both the context and the heterogeneity of the student body.
- The choice of the contents of teacher training in order to enable teachers to discuss their teaching, according to the features and the principles of the school discipline, and to provide their classroom presentations with responsibility and awareness.

The French educational context, which features a national curriculum determined by the Education Ministry, acts to influence the structure of teaching standards. As opposed to the UK, for example, the French system does not include a national assessment based on standards for each year and for each program component. According to pedagogical tradition, technology teachers implement their discipline with a wide degree of freedom. They are allowed to draw up their lesson plans and orient their teaching in a way they feel to be the most effective. It is thereby essential for learning assessment to be integrated into the foundations of the discipline. Technology education, defined as a discipline structured by technical experiences and practical tasks, requires an assessment in accordance with this set of principles (Lebeaume & Martinand, 1998, 2002). New programs identify three components in assessing pupils: participation and involvement within a teamwork setting associated with a project assignment; skill development associated with these particular tasks; and mastery of a few basic skills required for all pupils upon completion of each degree, in order to pursue the next higher degree program. At the end of the middle degree, they must be able to use measurement tools (e.g., electrical regulator, sliding gauge), operate equipment (e.g., soldering iron, drilling machine), and be comfortable with presentation tools such as scheduling or matrices. In addition to the know-how acquired, a certain amount of knowledge, not defined in words but in ideas, proves necessary to querying, understanding, organizing space and time, and making choices. From this perspective, examples include syllabus notes, production plans, design proposals, market studies, cost estimations, and product life cycles. Upon graduation from junior high school, the student assessment calls for the presentation of a technical project as a means of explaining decisions and choices and of using computer-assisted tools. Students are asked to establish a relationship with their work and the corresponding technical reality and then to produce an explanation that includes notions such as value, flux, (needs defining) constraints, standards, functions, and market. The complementarity of these three components of the assessment serves to maintain consistency in the discipline. Since project tasks lie at the heart of school activities, the experiences turn out to be more educational than merely skill-building or knowledge-building. Assessment is to be fundamentally included within the school discipline.

Implementation of the discipline also requires compatibility with the highly distinct set of school parameters: facilities, environment, organization, timetable, teachers, and pupils. The “technology” structure needs a certain degree of built-in flexibility. This characteristic is apparent by virtue of the decisions required by the teacher in the choices available as regards technical project components. Teachers have to choose two scenarios from among the three, with this choice depending on the local context. They must also decide on the technical product, the resources allocated, the conditions or constraints, and the stated goals and references (small vs. big firms, familiar or not to the pupils, overlapping or not with school practices). These multifaceted choices thereby generate diverse combinations of the organized tasks and different approaches to technology education. Among the range of technology education formulae, the organizational framework facilitates the maintainence of consistency within the discipline.

However, the existence of this discipline also presupposes new perspectives opened by means of controlled innovation. A school discipline cannot simply reproduce the same activities anytime and anyplace. Hence, innovation within the predominant framework offers significant potential for updating and shaping the future of technology education.

The contents of technology teacher training display the consequences of the fundamental principles adopted by new technology education programs in France. These contents can be organized around three main themes:

- Knowledge of the programs and of the discipline, for the purpose of identifying the broadest decision-making spaces.
- The skills involved in the pedagogical implementation of tasks and activities in conjunction with pupils, facilities, etc., to enable teachers to provide technology education, regularize teaching situations, adapt situations by taking account of pupils' reactions, institutional requirements, etc.
- The skills necessary for critiquing the relevance of academic situations in order to control the technical nature of pupils' tasks, discuss their significance with respect to external references, and defend their orientation in light of the purposes. This aspect relies upon negotiating with the method, its three components, and their relationships.

The contents of this didactic teacher training are not organized into syllabi of vocational techniques, but rather as the ability to deliberate about technology education in its current configuration and perspectives. Technology educators, defined as the specialists in this branch of teaching, are required to possess expertise in all aspects of the school discipline for which they have been assigned responsibility.

Method Employed at the Core of Technology Education

To conceive of technology education today as a disciplinary curriculum requires certain conceptual tools in order to identify key issues and make pertinent design and implementation decisions. Method provides a means for representing the objectives of the discipline in light of all its features, specific characteristics, nature, and conditions of existence. The authenticity of this discipline is fundamentally necessary because of its educational purpose in the compulsory general school system.

This analysis of the context specific to France also serves as a proposal to other school disciplines and to other countries. It clarifies the fact that technology education exhibits fundamental characteristics and the infeasibility of designing a technology education program with a model imported from another discipline. Its historical evolution and the alternation of methods have revealed the major effects resulting from its marked structural approach.

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References

Combarnous, M. (1984). *Les techniques et la technicité* [The techniques and the technical nature]. Paris: Editions sociales.

Deforge, Y. (1993). *De l'éducation technologique à la culture technique* [From technology education to technical culture]. Paris: ESF.

de Vries, M. (1994). Technology education in Western Europe. In D. Layton (Ed.), *Innovations dans l'enseignement des sciences et de la technologie* [Innovations in science and technology teaching-learning] (pp. 31-44). Paris: Unesco.

Foster, P. N. (1997). Classifying approaches to and philosophies of elementary-school technology education. *Journal of Technology Education, 8*(2), 21-34.

Lebeaume, J. (1996). *Ecole, technique et travail manuel* [School, technique and manual work]. Paris: Delagrave Z'Editions.

Lebeaume, J. (2000). *L'éducation technologique: Histoires et méthodes* [Technology education: Histories and methods]. Paris: ESF.

Lebeaume, J., & Martinand, J.-L. (1998). *Enseigner la technologie au college* [Teaching technology at junior high school]. Paris: Hachette.

Lebeaume, J., & Martinand, J.-L. (1999). Technology education in France: A school subject. In W. Theuerkauf & M. J. Dyrenfurth (Eds.), *Proceedings of the International Working Seminar of Scholars in Technology Education, Washington DC* (pp. 175-182). Braunschweig, Ames, Germany: EGTB-Wocate.

Lebeaume, J., & Martinand, J.-L. (2002). Technische bildung: Ideologische und theoretische aspeckte [Technology education: Ideological and theoretical issues]. In G. Graube & W. Theuerkauf (Eds.), *Technische bildung: Ansätze und perspektiven* [Technology education: Foundations and perspectives] (pp. 161-171). Frankfurt am Mein, Germany: Lang.

Martinand, J.-L. (1995). The purposes and methods of technological education. *Prospects, 25*(1), 49-56.

Petrina, S. (2000). The political ecology of design and technology education: An inquiry into methods. *International Journal of Technology and Design Education, 10*(3), 207-237.

Raat, J., de Vries, M., & Mottier, I. (Eds.). (1995). *Teaching technology for entrepreneurship and employment, PATT-7 Conference Proceedings.* Eindhoven, The Netherlands: PATT Foundation.

Zuga, K. (1997). An analysis of technology education in the United States based upon a historical overview and review of contemporary curriculum research. *International Journal of Technology and Design Education, 7*(3), 203-217.

International Collaboration in Secondary Level Education

By Dr. Tom Loveland, Dr. Hidetoshi Miyakawa, and Yoshitaka Hirayama

Global Education

Over the last 20 years, the economies of the world have been linked closer and closer together. The passage of the North American Free Trade Agreement (NAFTA) and the creation of the Euro currency in Europe are just two examples of how the world economies are becoming intertwined (McLaughlin, 1996). Transnational corporations have operations scattered across the globe to take advantage of access to raw materials, information, and labor. These corporations recruit and want to preserve their productive global workforce (Branson, 1998; Franks, 1998). The largest transnational corporations have budgets greater than many individual countries. The world is viewed by these corporations as a single global marketplace (Branson, 1998). The increasing vitality of the global economy has meant change for countries, businesses, and workers. Countries find that they no longer have total control over information and their local economies. Autocratic countries such as China and Iran are trying, unsuccessfully, to block their citizens' access to information through the Internet. Economic meltdowns in Argentina and Thailand in the late 1990s had far-reaching impacts on the economies of other countries. Businesses find that they have to adapt to the new business world or fade into obscurity. Workers find that they need new skills to compete globally.

The interconnectedness of the world has been aided by the proliferation of personal computers and the Internet. Inexpensive e-mail allows people from different countries to communicate instantaneously with each other. Organizations, educational institutions, and governments have contributed to the explosion of cross-border information exchange.

These changes and new realities have been described as a new age of interdependence. This interdependence evolved from world trade and international capitalism (Hughes & Ortero, 1989). Interdependence is most evident in the areas of international trade, environment, politics, telecommunications, transnational corporations, and international travel (Fish, 1982). The new global culture is placing new demands on the people of the world. Production is no longer restricted to geographical location so workers need to be more globally astute. According to Scarborough (1991), citizens need to understand the changing technologies, workplace adjustments, and competitive pressures. Fish (1982) confirmed this by stating that people need to be more aware of and more effective participants in the global economy.

Lauda (1992) declared that students throughout the world are internationally undernourished because education systems are too narrowly focused on rigid content areas and national issues. Globalization is a focus that the business world has embraced while education has tended to be more inwardly focused (Scarborough, 1991).

Global education is the means to teach the world's citizens about the globalization trends. According to the U.S. government report *Critical Needs in International Education* (National Advisory Board on International Education Programs, 1983), "it is in our schools, however, that the greatest progress can be made. International and intercultural studies should receive more attention and higher priority" (p. 7). The report goes on to promote the learning of international awareness, cultural sensitivity, and communication skills from foreign language and intercultural studies. Franks (1998) found the following:

> As the world grows increasingly interdependent, we discover even more opportunities to learn and work from each other about cooperative education. All over the globe, nations face a critical need to develop and maintain a supply of their most valuable resource: trained and productive workers. Work-integrated education has emerged as a viable means to that end. (p 72)

High school students are preparing themselves for college and future careers. Students in discrete subject courses are not given the bigger picture about the internationalization of the world. Students miss the connections of how all of these areas are interlinked. An opportunity exists in the schools to solve this dilemma. Secondary-level technology education classes offer a curriculum that encompasses the study of technology with links to all academic classes. A technology education lab filled with Internet accessible computers and equipment is the best location to use distance learning tools and research to create a curriculum that teaches students about international culture, values, and understanding. This program is accomplished by creating a collaborative program for the students to unite with partners in other countries. The goals of this collaborative effort are to teach students in both countries to be more respectful of each other's cultures, to create long-term friendships between the teenagers, families, schools, communities, and countries, and to see the relevance of studying global issues and perspectives. McLaughlin (1996) summarized the importance of global education by stating "global education attempts to teach people how to live in a world that is increasingly interconnected and interdependent. This method of education works to establish cross-cultural understanding and to develop cooperative attitudes needed to solve world problems" (p. 15).

The Japan-Florida Teens Meet Project

Yumegakuen High School or Dream High School in Tsu City, Mie-ken, Japan, was established in 1997 as the first school in Japan that has comprehensive courses as a forerunner of Japanese education reform. High schools in Japan offer either academic courses for students who go on to university studies or vocational courses for students who go into immediate postsecondary employment. The new comprehensive courses at Yumegakuen High have led to a mixture of students and curricula that is unusual in Japan. Due to this educational reform being conducted by the Ministry of Education, Culture, Sports, Science and Technology (Monbusho), Yumegakuen High School is equipped with high tech computers and teleconferencing facilities. An international studies teacher at the school was looking for a partner school in foreign countries and registered the classroom at the Web site of ePALS (http://www.ePALS.com). ePALS is dedicated to creating partnerships between schools across the world. When the teacher signed up in October 1999, there were 36,000 classrooms registered. As of July 2003, 81,514 classrooms were registered.

Several weeks after this teacher registered with ePALS, a technology education teacher from Ridgewood High School in New Port Richey, Florida, wrote to suggest a collaboration. It was a very nice and interesting offer because besides the educational purpose of the teleconference, the American teacher showed understanding toward the idea of promoting the school's image within the local community. The school is new and relatively unknown in the community of Tsu-City. It was thought that the collaboration could help recruit good students who would be suitable for these wonderful facilities.

A video teleconference test was held on November 18, 1999, for the two teachers to meet live to discuss curricula and ideas. The students in the two classes decided to call their collaboration the Japan-Florida Teens Meet Project (JFTMP). Activities were developed for the students to work on group projects and individual assignments. On December 14, 1999, students with guests met their overseas friends for the first time live through a video teleconference. This event included welcoming statements by the two school principals, introduction of guests (school board members, parents, district technology supervisors, reporters), some student activities, and question/answers. One of the activities the students did was a math dollar/yen conversion exercise. Students researched what the current conversion rate was and then calculated the cost of teen merchandise in both dollar and yen denominations. Comparisons were then made about the availability and costs of items the teens were interested in. The teen items were randomly pulled out of a hat to add some excitement to the event. This first teleconference was a great success and the media favorably reported it.

In late spring of 2000, plans were presented to the students about an international space station project. American and Japanese students would work on transnational student teams to conceptualize, research, design, and construct a 1/20th scale model international space station. The students had to design a sustainable environment built for teenagers living long term in space. The teams focused on essential modules of the international space station: living space, water-based systems, command, solar power, and scientific experiments. Two initial balsawood modules, including command and water-based systems, were completed by the American students and shipped to Japan in early June 2000. During the 2000-2001 school year, advanced technology studies students completed the rest of the modules for shipment to Japan. The design of the international space station modules was developed using a WebQuest format. This was placed on the World Wide Web for students and parents to access outside of school. The main JFTMP Web site is at http://www.tcp-ip.or.jp/~hirayama/jftmp.

Two teleconferences were held in the fall of 2000. New students in both countries were introduced to each other. One of the teleconferences included 100 fifth graders from a local elementary school in Tsu City. A Japanese foreign exchange student at Ridgewood began participating, adding to smoother communications and understanding. Over the next several years, media in both countries reported about the teleconferences and collaborative activities. Yumegakuen High School received good publicity and attracted more students. In the spring of 2000, about twice as many students took the entrance exam than there were openings for admission.

In January 2000, the American teacher received a grant from a local foundation to travel to Japan in the summer of 2001 for two weeks with eight Ridgewood students. Five of the eight students traveling were from the technology education classes. Two days were used to visit Yumegakuen High School so the students could meet and participate in shared activities. During the visit there, the Japanese and American-built components of the model international space station were assembled and put on display. The event was covered extensively in the Japanese press. A photo was taken of the JFTMP students that day with their completed model space station. A JFTMP goal was to have that photo flown to the international space station with a Japanese astronaut. A photo of the astronaut holding the JFTMP picture in space would then be enlarged and put on display in both schools.

A decision was made to make a video project the centerpiece of the 2001-2002 school year. The video, Smoke and Mirrors, was a dramatic anti-tobacco story that had scenes taped in both countries and in both languages. Two different versions of the video were produced. In addition to memorizing their English dialogue, the American students had to learn Japanese for the same scenes. The Japanese had to learn their lines in Japanese and English. American students edited the English-only version and the Yumegakuen students edited the Japanese-only version. Both videos were premiered during a teleconference in March 2002. The videos were partially funded by the Students Working Against Tobacco (SWAT) organization in Florida.

The Future of JFTMP

In addition to the video projects, the teachers are collaborating on expansion of the JFTMP Web site. They are working to include more schools in their international collaboration because of their belief that high school students benefit from this experience. American students are taught critical thinking skills, but Japanese students are expected to be docile. Now in the age of information technology, Japanese teachers are beginning to realize the importance of critical thinking. Japanese businesses are realizing that having docile workers is not helpful to their companies in the global economy. This doesn't mean the companies need argumentative workers. They need workers who think differently and share their ideas. These different ideas can be used creatively by the companies and/or classrooms to generate better ways of doing things. This is how society can improve. The JFTMP is designed to make the most of international collaboration and friendships.

Obstacles to Collaboration

There are obstacles to the success of international collaborations. According to Weinbaum and Rogers (1995), "such projects require a rethinking of traditional school schedules, as well as providing opportunities for teachers to learn new material, design curricula, plan with their colleagues, and reflect on the effectiveness of their practice" (p. 22). Obstacles in the JFTMP program were summarized into several categories: time difference, school year schedule, language barriers, and difference of interests.

The prime obstacle was the time difference between Florida and Japan. This obstacle was overcome by the Americans coming back to school in the evening to meet live with their Japanese partners who were in their regularly scheduled first period class the following day. The Japanese don't observe daylight savings time so it became important to check an international time zone Web site to make sure the meetings started at the correct time.

Another obstacle was the difference in school schedules. The school year in Japan starts in April,whereas American schools start in August. JFTMP started in 1999 and some of the active Japanese students have already graduated from high school and are now studying at college. When the American students came to Japan, most of their e-mail friends had graduated. A secondary goal of the JFTMP Web site was to keep graduates informed about current collaborative activities.

Some challenges were related to the nature of the distance learning technologies themselves. The use of ISDN lines cost the schools about $200 per teleconference. The two schools shared responsibility for these costs although both schools had to justify the phone costs to administrators outside of their schools.

Language was a major source of concern prior to the teachers talking live with each other. It was helpful to the Americans that the Japanese teacher fluently spoke English. Ridgewood High is in a rural suburban area with little opportunity for native Japanese speakers for translation assistance. The language barrier is a continual hurdle, but English is the target language for Japanese students to learn so this is a part of the purpose of education and the teleconferences.

Another challenge was in the shifting interests of the students. Yumegakuen is a mix of high school and adult learners. Some of the adult students were mainly interested in learning about foreign cultures and English rather than mechanical projects such as the space station. The JFTMP program shifted with the American teacher from Ridgewood High School to Marchman Technical Education Center beginning with the 2002-2003 school year. The newly linked Marchman class was television production so the teachers agreed to focus JFTMP ideas towards video projects. This shift appeared to satisfy the interests of the adult and high school age students at both schools.

Due to a lack of curriculum materials on international collaborations at the secondary level, the teachers found that they had to develop and write the curricula themselves. Plans are underway to expand the core schools to include more Florida and Japanese high schools into a larger JFTMP consortium. This will expand the curriculum resources for all teachers through the sharing of ideas and experiences.

Information Technology Education in Japan

> According to Miyakawa (1998), current advancement in communication technology is allowing for ever increasing access to information. This not only promises to change people's life styles, but also may change the value system of society itself. In such a "technological" society, those who can readily adjust to these changes into technology will do very well while those less able to adjust may be left behind in the information revolution. (p. 29)

The information society is highly advanced in Japan as it is in the United States. The information technology revolution in Japan is pressing leaders to consider how to manage the information society in all fields including industrial technology, business, society, and home. Schools are no exception and are now trying hard to adjust to the information society. School computers are becoming networked so the worldwide Internet is becoming more available. It is therefore important for the education field to promote effective and efficient use of computers and to develop new learning content and curricula.

Information technology education in Japan began in 1985. It has been promoted aggressively and continuously since then. Various policies have been adopted such as distributing money to school education budgets and training teachers through in-services. As a result of this investment and the support of Japanese parents, almost all Japanese students take information technology education, a lowersecondary level elective.

In 1999, surveys conducted by Monbusho showed the state of information technology and computer usage in Japanese schools. Ninety-nine percent of the 39,096 schools had computer equipment. Of those schools, 22,449 were connected to the Internet. Internet guidelines have been established in 9,477 schools. The number of schools with their own Web site was 7,850. Among the 38,829 schools with computers, 27,205 were connected by LAN.

Of the 886,768 Japanese teachers, 66% can operate computers and 32% can teach using computers. The subject area with the highest usage and ability to teach using computers is in technology education. Of the 10,541 technology education teachers, 94.5% of these use computers.

There are issues that affect the ability of Japanese schools to participate in collaborative projects with schools overseas. Monbusho is addressing these with the following implementation schedule for information technology:

1. All public elementary, lower secondary, and upper secondary schools were connected to the Internet by the end of 2001.
2. By 2004, LAN networks will be installed in all public schools.
3. By 2004, all private schools are targeted

for Internet connection.

4. All 900,000 public school teachers took an in-service Project for Enhancing Teacher's Information Literacy by the end of 2001.

In addition to Monbusho's plans, Japanese leaders in the technology education field have raised seven other information technology issues that should be addressed by educational institutions. Hardware that has functions required for school education should be equipped in all classrooms that need it. It is necessary to make computer equipment available for anytime, anywhere, and anyone. Effective and efficient educational software should be researched, developed, and distributed at low prices to schools. Educational objectives about information technology should be clarified and all teachers should examine the new content and methods. Connection charges to Japanese schools should be substantially reduced. Teachers and students should be thoroughly taught ethics and morals in the appropriate use of the Internet. Finally, teacher training in information technology should be planned and conducted according to the needs of teachers. Steps like these can lead to more connections between technology education classrooms in Japan and the rest of the world.

Benefits of Collaboration

There are two major benefits of international collaborations: the learning is authentic and contextual-based, and student motivation to learn increases substantially. Authentic instruction is a way of linking classroom work to real work situations that employees face out of school. Blank (1997) referred to authentic instruction as "any instructional strategy, model or technique that involves students in learning something that is useful or important beyond the school setting and that engages them in a manner that helps them construct new knowledge or develop deep understandings or insights" (p.15). It is a teaching strategy and project-based curriculum that mirrors work that adults perform in their employment, home, or community. Weinbaum and Rogers (1995) pointed out that situating education in real-life contexts is an answer to the concerns of vocational program critics who feel there is a gulf between what is in education and what the actual human resource needs are of the U.S. economy. Resnick (1987) concurred by recommending that schools concentrate on teaching people to be adaptive learners able to negotiate the inevitable transitions that occur in the workplace.

High school graduates will be facing a far different work world and will therefore need to learn in far different ways in the classroom. Global education was chosen as an overall theme to enable students to work on real-life projects that increase problem-solving skills, create unique team settings, and help students become better communicators and international citizens. The two JFTMP teachers directly observed many benefits to the students and schools from participation in collaborative projects.

For students:

- Increased technical skills.
- New understandings of applied math and science.
- Better writing and communication skills.
- Increased technological literacy.
- Increased classroom motivation and excitement about learning.
- New concepts of what a "team" means.
- Less stereotyping of other cultures.
- Broadened student views and perspectives.
- Understanding on the implications of the global economy.

For schools:

- Enhanced parental support.
- Opening communication lines with other education systems.
- Awareness of the advantages of using new technologies.
- Promotion of new and creative school curricula.
- Raised education standards at local schools.

Planning an International Collaboration

High school teachers interested in initiating an international collaboration with a school in a different country face many challenges. Using the Decide phase of the DDD-E model (Barron & Ivers, 1998), teachers can systematically develop authentic learning, multimedia projects

with teachers from other countries.
The broad challenges that face teachers during the planning section include:

- Fitting the project within the scope of district and state curriculum mandates.
- Finding a sister school with similar interests, curricula, and distance learning technologies.
- Assessing their school's distance learning technologies.
- Developing the prerequisite skills to use these technologies.

Setting Instructional Goals

The first task for the teacher is to set instructional goals. According to Barron and Ivers (1998), instructional goals may include responding to different student learning styles, promoting cooperative learning, enhancing vocational-academic integration, developing critical-thinking and problem-solving skills, and fostering presentation and speaking skills.

Broad and content-specific instructional goals were developed for the JFTMP collaboration. The first goal of the collaboration was to prepare students for careers in the global economy by having the project mirror projects done in the workplace. Broad instructional goals for this collaborative effort were to teach students in both countries to be more respectful of each other's cultures; to be more aware of the cultural differences; to create long-term friendships between the teenagers, families, schools, communities, and countries; and to see the relevance of studying global issues and perspectives.

Deciding on the Project

After developing the instructional goals, the teacher now selects and designs a multimedia classroom project. International collaboration projects are complicated and require comprehensive preparation and design. Teachers have the choice of joining an education-based network with developed curricula, projects, and preselected international classrooms or develop their own original international collaboration. According to Bradsher (1996), "identifying overseas schools with the means and desire to pursue a project that fits your curriculum and students' needs and interests can take a lot of time" (p. 50). Before contacting a teacher from overseas, the American teacher should study the culture and education system of the country he or she wishes to collaborate with. Initial studies will help to increase the teacher's cultural sensitivity, knowledge of the other education system, and make for a more polished introduction.

It is important for teachers to communicate openly and clearly about goals and project ideas with their partners. Projects will need to be started in incremental steps for several reasons. Overly enthusiastic American teachers may be intimidating to teachers from other cultures. Education systems in other countries may have their coursework rigidly set by a national curriculum that makes it difficult to accommodate comprehensive collaborative projects. Finally, other cultures may be used to thoughtful, team-based decision making. American teachers will need to be aware of and respectful of these differences.

Development of Prerequisite Skills

The third stage of the decision process is to develop the prerequisite multimedia skills within the teacher and the students to improve the project's success. These skills may be technological and related to global communication. Thach and Murphy (1994) found that

> the distance learning instructor needs skills and knowledge in eight major areas: 1) communication and feedback, 2) promoting interaction between and among learners, 3) teamwork and collaboration, 4) administrative and support services, 5) conducting learner needs assessments, 6) distance learning technology and its impact on learners, 7) identifying learning styles, and 8) developing a systems perspective of thinking. (p. 16)

Distance learning technologies include Internet (research, e-mailing), desktop teleconferencing (NetMeeting, CUCMe), video teleconferencing (Picture-Tel, ISDN lines), and interactive multimedia (PowerPoint, Web page design). The teacher should take in-services or classes or use study time to master these technologies before attempting to teach them to students. Fortunately, American students have been exposed to and have access to many of these technologies. In some cases, the students will be the expert and the teacher the learner. All students should be familiar with basic computer skills and the skills required for the specific multimedia project.

American students will need an introduction to and practice in global communication skills. Their written communication with partners through e-mails will need to be clear, concise, and punctuated properly. During the video teleconferences, normal American teenage habits of wearing baseball caps, having arms folded, using slang, or wearing provocative clothing may be seen by foreigners as extremely rude and offensive. When speaking with non-native English speakers, it is important to slow down, not raise voices, and give plenty of time for translation. Students will need to be made aware of these communication skills. The importance of projecting a friendly, team-oriented image with respect for cultural diversity can not be overstated.

Assessing Resources

At this fourth stage, teachers begin looking at their classroom resources to see if there are hardware or software gaps. They would begin by thinking about how many computers they will need to keep the students productive. They will need to know how many of the computers will have Internet access. What level of Internet access should the teacher allow the student is another important question. If Web sites with classroom photographs are being considered, a copyright talent release form will have to be written and distributed to parents. Teacher funds may need to be set aside for the cost of the ISDN lines used during teleconferences. Overseas mailing costs for curriculum materials will have to be arranged. Software might have to be installed and tested. If the computer and distance learning technologies are outside the classroom, the teacher will have to set exact times and schedule these with the schools in both countries. The teacher will also need to investigate educational Internet sites for resources. The technology studies teacher spent countless hours looking at NASA sites on the international space station. Before writing URL addresses into student handouts, a teacher should check all to make sure they are still operative.

Conclusion

The use of computer-mediated communication is increasing exponentially in the United States. Whether schools realize it or not, this increased use of technologies works to engage learners in ways that increase understanding and student success. When instructional techniques enlist more than a learner's logical/mathematical intelligence, student motivation to learn increases. Students experience success and conclude that school is relevant in their lives.

When global education, international collaboration, and authentic/applied learning projects are incorporated with increased use of computer-mediated communication technologies, student interest and motivation to learn is enhanced. All students, gifted to specific learning disability, can benefit from exposure to this instructional strategy. The role of the teacher is crucial. Instructional strategies should be designed to include computer-mediated communication technologies. The benefits to students far outstrip the planning that is required. Computer-mediated communication can form a powerful integrated model of human learning and intelligence. This model provides teachers with the tools to meet high standards. The outcome of comprehensive planning is students with better attitudes and understandings of the cultures and values of students in other parts of the world. Students will become lifelong learners, adaptable to change, and better prepared for their future work and careers.

In the initial phase of an international collaborative project, the teacher will need to work diligently to plan and organize before presenting the project to their students. This planning stage includes setting the instructional goals, deciding on the project, developing prerequisite skills in themselves and their students, and assessing their resources. The benefit of this planning will be an international collaborative project that affects learners and teachers in profound ways. According to Jensen and Loveland (2000), "when learning environments mirror the restructured work that students will eventually enter, they provide students with opportunities to see how what they are learning in school adds value to their lives" (p. 371). The new interconnectedness of the world is a reality that teachers can utilize to develop projects that will prepare their students for the career world they will be facing upon graduation. According to Thach and Murphy (1994):

> Suddenly, separate cultures, laws, regulations, and customs have been brought together in a kaleidoscope of learning. The result is chaotic, fun, challenging, and anxiety-producing; it challenges all of those who work in the field of distance education

to broaden their perspectives, to strive for the implementation of best practices; and to encourage collaboration while respecting individual, group, and institutional integrity. (p. 17)

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References

Barron, A., & Ivers, K. (1998). *Multimedia projects in education: Designing, producing, and assessing.* Englewood, CO: Libraries Unlimited.

Blank, W. (1997). Authentic instruction. In W. Blank & S. Harwell (Eds.), *Promising practices for connecting schools with the real world* (pp. 15-21). Tampa: University of South Florida.

Bradsher, M. (1996). Making friends in the global village: Tips on international collaborations. *Learning and Leading with Technology, 23*(6), 48-51.

Branson, M. (1998). International education, citizenship, and national standards. *Social Studies Review, 37*(2), 18-21.

Fish, L. (1982). *Alternative patterns of international collaboration for school improvement: An analysis of activities of the OECD/CERI Pacific Circle Consortium.* Portland, OR: Northwest Regional Educational Laboratory. (ERIC Document Reproduction Service No. ED 214 827)

Franks, P. (1998). The world association for cooperative education: Filling a need for a strong global partnership. *The Journal of Cooperative Education, 33*(2), 68-73.

Hughes, S., & Ortero, G. (1989). Global education for the secondary and college student. *The Political Science Teacher, 2*(1), 21-23.

Jenkins, J., & Loveland, T. (2000). Educational opportunities in the global village. *International Journal of Educational Reform, 9*(4), 369-372.

Lauda, D. (1992). Internationalizing the curriculum in technology education. In D. Blandow & M. Dyrenfurth (Eds.), *Technology literacy, competence and innovation in human resource development* (pp. 464-470). Weimar, Germany: Thuringer Algemeine.

McLaughlin, C., Jr. (1996). Implications of global change: Technology education's role. *The Technology Teacher, 55*(5), 14-18.

Miyakawa, H. (1998). Study on the fostering of self-educability in technology education: A consideration about practical teaching materials in "information technology" area. *The Bulletin of Center for Research, Training and Guidance in Educational Practice, 1,* 29-37.

National Advisory Board on International Education Programs. (1983). *Critical needs in international education: Recommendations for action.* Washington, DC: Department of Education.

Resnick, L. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13-20.

Scarborough, J. (1991). International perspectives on technological literacy. In M. Dyrenfurth & M. Kozak (Eds.), *Technological literacy* (pp. 54-55). Peoria, IL: Glencoe.

Thach, L., & Murphy, K. (1994). Collaboration in distance education: From local to international perspectives. *The American Journal of Distance Education, 8*(3), 5-21.

Weinbaum, A., & Rogers, A. (1995). *Contextual learning: A critical aspect of school-to-work transition programs* (Report No. RR1172012). Washington, DC: Academy for Educational Development, National Institute for Work and Learning. (ERIC Document Reproduction Service No. ED 381 666)

Secondary School, University, and Business/Industry Cooperation Yields Benefits to Technological Education Students

By Dr. Ann Marie Hill

Political Dimensions of School and Community Cooperation

The secondary school work environment of technological education teachers in Ontario has changed. These teachers cope with pressures from the Ontario Ministry of Education (OME), business and industry, and the public at large for increased community involvement in education and for relevant student learning that is connected to life outside of school. This is what Ruddick (1999) referred to as the pressured, political dimensions of partnerships. Many reports have portrayed this dimension of partnerships at the national level in Canada (Dave, 1976; Dryden, 1986; Human Resources Development Canada, 1994, 1995) and at the provincial level in Ontario (Premier's Council, 1994; Royal Commission on Learning, 1994a, 1994b, 1994c, 1994d).

In Ontario, a past policy document (Ontario Ministry of Education and Training [OMET], 1995) for secondary school technological education introduced the concept of partnership. One chapter, titled "The Learning Environment," consists of four subsections: the facility, resources, the role of the teacher, and process and project management. The latter subsection states:

> It is necessary for students to move to different areas in the school or out into the community in order to complete projects. The teacher will need to work in close co-operation with all stakeholders (students, parents, community members, other teachers, and administrators) to co-ordinate the contributions of all those participating in the students' activities and to address any concerns related to them. (p. 13)

The next chapter, titled "Considerations in Program Development," consists of seven subsections, one of which is school-community partnerships. This subsection argues:

> In order to maintain and strengthen their connections with the community, schools must involve community members and groups in its planning, delivery, and evaluation of all broad-based technology programs. Schools should consult with community representatives on a regular basis in order to identify new needs as they arise and allow programs to be adjusted accordingly. (p. 16)

A new policy document (OME, 2000) now replaces the 1995 document, but the idea of partnerships remains.

> In general, technological education programs should be designed to take advantage of local opportunities for students to combine work experiences with classroom learning. Programs may be modified to reflect community needs. In-class and out-of-class components must be carefully matched and monitored so that students' experiences are relevant and authentic. (p. 200)

Community-Based Projects in Secondary School Technological Education

Research in technological education (Hill, 1996, 1997, 1998, 1999) has documented that it is not solely the project that is important in project-based learning. While the project provides the environment for students' active engagement in their learning, the teacher alone frequently defines the project. The experience of making such projects may not be directly relevant, authentic, or meaningful to students' lives. Dewey (1977) stated: "It is not enough to insist upon the necessity of experience, nor even activity in experience. Everything depends upon the quality of experience" (p. 27). He described two aspects of quality: "There is an immediate aspect of agreeable or disagreeableness and there is its influence upon later experience" (p. 27).

Projects become more meaningful to students when the technological problem-solving experience is situated in and relevant to their lives, such as involving them in the community in which they live. A real-life context sets real human needs for projects and this in turn establishes relevant activities for authentic learning. The learning environment in this approach shifts from a situation of project-based learning, which is typically teacher conceived and of less interest or relevance to students, to community-based project learning, where students are involved in projects from their community, called community-based projects. The community is typically the immediate community serviced by the school, but it can expand beyond local geography. Community partners can be business or industry-large or small—which are located in the community, local families, the school itself, or the school board. Students design projects for community partners, and the community partners provide resources and expertise to students.

A community-based project approach to learning allows students to meet real human needs in their technological education courses; they carry out technological design for an identified need of a community member. Such projects encourage working cooperatively with people inside and outside of school. As students meet with their community partners and with experts in the community, they recognize other people as important learning resources. They also become motivated and engaged in their own learning. Programs that reach out to the world outside of school provide a means for relevant student learning and a stimulating and viable educational experience for students. The gap between school and life outside of school is also reduced as students see applications for what is learned in school and are presented with a new range of choices and opportunities from these community experiences.

Community-Based Projects Applied in a Manufacturing Technology Program

Hill and Smith (1998) examined a secondary school in southeastern Ontario where graduates and others familiar with the setting spoke highly about a particular program and the teacher who had received national recognition and teaching awards for his work in the school. The teacher's program in technological education consisted of courses in Manufacturing Technology, Grades 9 through 12. One Grade 10 class and one Grade 11 class were studied intensively during a five-month period.

The Curriculum

The curriculum content for both Manufacturing Technology courses, Grade 10 and Grade 11, included: the technological design process, interpreted as a problem solving process; mechanics (stress and strain, strength of materials, gears, pulleys and belts); power systems (electrical, pneumatic, hydraulic); control theory; skills building using tools and equipment (including computers); and group work. There were also different community projects ongoing simultaneously in any one course as students worked in groups with different community partners.

Community-based projects during the year of the research ranged from bike cars, a bike trailor, and classroom objects for teaching technology at local elementary schools to projects with local business and industry. A gardening table and a laundry bin device were created for a local retirement home, and a spool rewind system prototype was created as part of the production process of a large multinational tire producer.

The Teacher

The teacher had worked as an engineer in a large multinational firm and had changed careers to become a teacher. He had begun his teaching career teaching physics and mathematics and after several years became a technological education teacher. His main reason for the change was that the pedagogy used in technological education courses "fit" with his philosophy of teaching. In an interview, the teacher described the impact that the change in subject area assignment had had on him, and his adoption of a project-based approach to teaching that included community involvement:

> I started teaching in the conventional manner. I was at the front of the class, you know, going away at a bunch of people sitting in front of me, and...my sense of what I got back was that people weren't learning. True, they were able to regurgitate, but that's not learning. They weren't learning. It wasn't registering....The material was fine, but somehow it just didn't have a context, and I was beginning to think about ways, at that point, about how to make it relevant to the kids....I think the context is really the important thing....You know, just teaching the physics or a mechanics principle in pictures doesn't compare to somebody going and picking up something, pulling on it, and then by drawing a little sketch...just having that tangible holding-on contact makes all the difference to me. And so it grew there. I started thinking, well if that's the case, why don't we try building something, and [I] began a long process of learning how to do that. (DH,[1] personal communication, March 13, 1996)

He described "learning in context" as "being able to put together the doing something and the understanding of doing something." His example of what he meant was based on life experience. "I was doing physics problems with my daughter...after doing a bunch of problems on paper, little pictures—I asked her 'What's that for?' and she didn't have any idea...that's why I say...it's not understanding...it didn't have connection to the kids' lives" (DH, personal communication, March 13, 1996). His life experience had led him to technological education where he involved the community in student projects in order to create a learning environment where students could learn in a context that was connected to their lives.

The Students

The students in these two classes were both male and female with a wide range of interests and abilities. The Grade 10 Manufacturing Technology class consisted of 14 students: 12 male and 2 female. Grades on completed courses toward an Ontario secondary school diploma (OSSD), across all subjects, ranged from 51% to 95% for the males and 78% to 96% for the females. The students' age varied from 16 to 19 years. There were 19 students enrolled in the Grade 11 class: 14 male and 5 female. Their grades on completed courses toward an OSSD ranged from 23% to 97% for the males and 62% to 100% for the females. This group had completed more OSSD courses. As well, their age range was more uniform ranging from 17 to 18 years. Student interviews from both grades revealed that students enrolled in the course for a variety of reasons: from gainful employment directly related to the technological education course to continuing on to university engineering programs.

Benefits of Community-Based Projects to Secondary School Students

Community partners, the school principal, and students all commented on the benefits of school and community cooperation in the delivery of technological education at the secondary school level.

Community Partners' Perspectives

There were many community partners associated with the Manufacturing Technology courses. Data from one large-sized company and one medium-sized company are reported below. Both reveal similar perspectives about the knowledge, skills, and values deemed important for high school students and how partnerships assist students to close the gap between school and life beyond school.

Large-sized company. A major international tire producer had worked with the secondary school for several years. Company contact people assigned to work with the school were selected for their technical abilities associated with class projects. One assigned contact person described his role in the cooperative project for that year: "I present them with the problem and allow them to come up with their own ideas without telling them what I think is the solution" (SD, personal communication, March 22, 1996).

Initially he described the skills, knowledge, and attitudes needed by students graduating from high school in terms of generic skills such as the ability to be flexible, solve problems, deal with any situation effectively and in a timely

[1] For purposes of anonymity in this qualitative study, pseudonyms in the form of initials were assigned to represent real names.

manner, continually adapt and learn, and work with other people on a team. He stated that specific skills were best learned in the workplace. "I think that technique and the ability to do, that is more what they learn [in the workplace]" (SD, personal communication, March 22, 1996).

When asked to explain why specific skills should be learned "on the job," he provided more detail. "The need for specific skills… is going to be really dependent on where you're trying to place them in the company." He explained that if an employee were hired as a welder or an electrician, he would hire "somebody who has some sort of detailed [skills] background." As such, the company would expect the applicant to bring these skills to the job. However, when an applicant was hired to work in production, the company provided specific training. "If you're talking about a lot of our production jobs, the skills that are involved are not things that you would normally learn from an educational institution," because the skills required were specific to that company's production process. When he described qualities of applicants who were hired to design and implement company projects, he said, "Then in my opinion you're looking more at a problem solver who works with other people" (SD, personal communication, March 22, 1996).

He cautioned against only specific skills training in secondary school. Instead, he described the role of secondary school technological education courses in terms of generic skills. "So the most important thing in my opinion wouldn't be learning a particular function or craft or whatever. It would be becoming generally knowledgeable and flexible, to be able to adapt, to learn" (SD, personal communication, March 22, 1996).

In discussion about students obtaining specific technical abilities while participating in community-based course projects, he recognized the importance of technical skills to make the artifact and generic skills to work in a group and move through the design process. He also recognized the value of creativity in these projects and the confidence that such a process instilled in students. "It's the getting there and the learning it...and getting the confidence of, 'Hey, I can do this! I can do more!', that attitude" (SD, personal communication, March 22, 1996).

Clearly, it was not only the acquisition and refinement of generic skills that moved student projects to completion. Knowledge and skills from many different technical areas were required for project completion. This large company also required, for certain jobs, skilled and technical employees, but even these individuals needed generic skills as well.

Medium-sized company. Interviews with the contact person from one medium-sized company, a retirement home, also revealed a need for generic skills in the workplace. This work environment used a different model for teamwork. First, all employees were part of a team. Second, the teams were comprised of people with different skilled backgrounds who worked together for a common goal—"to maintain the quality of life" for each elderly resident. "All our teams are composed of maintenance, housekeeping, health care aides, psychologists, right up to the administration. Every committee has those people on it" (LA, personal communication, March 22, 1996).

The contact person for this care agency described that while she brought to the team a skill, she was also required to move beyond a narrow job description when needed and to change her skills as the job evolved. She described job requirements as flexible ("My job here is housekeeping...but I also do other things...the cleaning staff [are] very involved with the residents...with the residents' care—emotional care"; LA, personal communication, March 22, 1996) and as requiring on-going education ("We have to attend care conferences.... Your job is not always what it appears to be"; LA, personal communication, March 22, 1996). She saw her role as sharing this with students, as well as providing them with project possibilities to better the life of the residents.

The School Principal

The principal was very supportive of all students' life goals. He believed in making school relevant so students' secondary school education would be meaningful to them. When talking about the qualities important for graduates, the school principal saw three important areas of an adolescent's development: personal qualities, general qualities, and specific skills. Personal skills were described as a sense of responsibility, recognition of the importance of learning, and honesty. General skills were described in terms of literacy, numeracy, science literacy, technical literacy, computer literacy, and data processing.

He talked about specific skills in the context of students in their senior high school years and students moving toward employment. Here, he pointed out the necessity and importance of specific skills. “If you’ve got two students going for a job in autobody...they both have the personal skills that allow them to function in the workplace. Who is that employer going to hire?....Well, my experience tells me they are going to hire someone with specific skills” (MD, personal communication, March 3, 1996). The principal recognized that school-community partnerships provided benefits to students. They provided relevant learning opportunities for students and helped close the gap between school and life beyond school.

Students

Both Grade 10 and Grade 11 students appreciated their Manufacturing Technology courses for the relevance the courses brought to their learning. The teacher’s reasons for engaging in this approach to teaching were qualified by what students said.

Grade 10 students talked about the benefits of community-based projects in their course. Their comments revealed that the course affected their learning in other subjects and their overall secondary school experience. They used words related to not boring (“constantly do different things,” “moving around,” “not formal,” “you don’t actually realize that you’re learning”) when talking about the course. They indicated that in learning by doing, the course was like real life and that the theory and practice combination made their learning more challenging. Community-based projects were described as providing varied, not narrow, experiences and that the combination of theory and practice afforded in community-based projects made learning relevant. “It gives you like, you know how school is. School, and then you want to grow up, and leave, do other stuff that has nothing to do with school. Both together, you don’t feel like you are doing it for no reason. Like most schooling is” (SA, personal communication, December 5, 1995).

Grade 11 students revealed similar benefits of community-based projects in their course. As well, they were cognizant of the social benefits of community-based projects. “If we didn’t do it, then a lot of things wouldn’t get done [in the community]” (HI, personal communication, November 17, 1995). “It’s profitable for both people. They [the community] get something that they can use, that they need, and we get the experience of building it, of working on it for an entire semester” (JE, personal communication, November 17, 1995). They also appreciated the challenges that this course offered them and they were aware of how it contributed to their plans for life beyond school.

These courses benefited students in more ways than just narrow skill acquisition. Problem solving, decision making, creativity, teamwork, social responsibility, trust, and continuous improvement and learning were evident in the community-based projects.

Impact of Community-Based Projects on Teachers

Course delivery through cooperation between secondary schools and the community has a direct impact on the day-to-day life of teachers. Hill and Hopkins (1999) wrote that from the teacher’s perspective, it is feasible to use community-based projects in secondary school settings. One important factor is simply to get started by establishing links with the community. Once this first step is complete, additional opportunities arise by word of mouth.

Structurally, there is very little change to a school day with this approach. There is the same number of classes per day and teachers still have to prepare for their classes. What changes is how teachers go about their teacher lives. Each day, each class, each period is never the same, never repetitive. Students’ needs and activities are never entirely predictable. However, the curriculum is predictable. Course content guides the course, but activities used to learn the content are not as predictable. At the onset of a course, the teacher spends a substantial amount of time thinking about how to match course content to community projects. Once projects are selected, the teacher must carefully schedule student acquisition of content to advance student projects.

The classroom setting also changes with this mode of delivery. There is a need for a technology laboratory or “shop” area, whether within or separate from the classroom. In addition, the teacher’s workplace moves beyond only the school and classroom/laboratory setting into the community. Community members both attend class and are part of the course. Also, students and teachers go to community settings. Human and nonhuman community resources of all kinds are sought out and used. Thus, teachers relinquish a more authoritative role in their classrooms for the role of facilitator.

The teacher's role changes significantly in this model from the conventional transmitter of knowledge to the facilitator of learning. The purpose for student learning is not because the teacher wants students to learn something, but because students need to learn to advance their community-based projects. The focus of class time is on the learner. The learning environment becomes more interesting for students and challenging for the teacher. The challenge is to develop the confidence to be a risk taker and to go beyond the boundaries of convention.

However, this pedagogical approach does not come without added pressures for teachers. There is pressure to succeed on various levels. Projects must successfully meet community needs and be completed within a negotiated time frame, typically by the end of a semester or at least by the end of the school year in the case of larger projects. The teacher takes on personal responsibility for successful completion of projects. The teacher's reputation and the program's livelihood rest on the teacher's ability to manage such a program. There are also day-to-day pressures that arise from teaching courses where students work on different projects. Attention to detail in the beginning weeks of school is paramount, as evidenced in the following excerpt from the Manufacturing Technology teacher's audiotape journal: "Getting these things set up and organized is probably the most important thing you can do; getting a proper definition of what the technology project is, getting a good relationship with the clients...getting the kids to understand the size and definition of the project" (DH, personal communication, September 6, 1995).

But this teacher believed that a community-based project approach was well worth the effort on his part. Experience had shown him that many students do not learn well in a traditional teacher-centered classroom. He still used more traditional approaches to teaching, for example, a 10-minute lesson at the beginning of class or a small teacher-focused project for content not covered through community-based projects. However, this represented teaching moments within the activities of the community-based projects, not a main pedagogical approach.

After several years of examining the community-based project approach in technological education courses, new teacher organizational skills and knowledge have emerged, including the ability of the teacher to:

- Have faith in students' abilities to learn. Relax in being a facilitator.
- Teach a short lesson of about 10 minutes at the beginning of every 70 minute class, and then trust and manage.
- Rearrange expectations of the teacher and students, for example:
  - Don't spend too much time with one group, one project.
  - Give students encouragement and clues, and then move to another group.
  - Encourage students to ask the teacher for help when needed.
  - Inform students that if they are waiting for teacher help, or for the community partner visit, etc., they should be doing some other activity while waiting.
  - If students need materials, they are responsible to make a list and give it to the teacher.
  - Inform students they are also responsible for their learning.
- Accept that they do not know everything, that they are not the purveyors of all knowledge for all projects. Students are responsible for their learning also. Then the teacher can focus on managing students' learning and projects.
- Be enthusiastic and energetic.
- Be an on-going learner.
- Use human and resource materials in the world outside of school.

Community-Based Projects and Teacher Education

Teacher education programs can model secondary school classrooms that link with the community. Remembering that artifacts, systems, and processes are supposed to meet human needs, in teacher education courses, teacher candidates would be required to find projects based on community needs. In doing so, they would experience the technological problem-solving process that they in turn would expect their secondary school students to engage. The community can be inside or outside of the class.

The teacher education program at Queen's University, Ontario, engages teacher candidates in both teacher-directed and community-based projects. In 1995-1996, examples of community-based projects to meet needs outside of the teacher education class were "The Emergency First Aid Backpack," a specially designed backpack to carry emergency supplies and equipment to remote locations; the "Exit Buddy," a device that enables firefighters to quickly locate exits in dark, smoke-filled rooms; "Uropia," a lightweight, portable rope course; "The Art Kart Centre," a space organizing system for elementary school classrooms; and a "Support Table" for last year's project, the "Arm Rehabilitator 2000." Projects that met in-class needs were a "Multimedia Interactive CD," an information program designed for the World Wide Web about Queen's University's technological education program; and an "Information Video on Broad-Based Technology" to introduce high school students, staff, and the local community to the study of technology in secondary schools.

In 1994-1995, examples of community-based projects were the "Arm Rehabilitator 2000," designed for stroke patient therapy at Saint Mary's of the Lake Hospital (Gubbels, 1995), and the "Environmobile 2000," a solar-charged battery land vehicle made from old bicycles and an old chair. The former met an outside community need while the latter met an inside (class) community need. In 1993-1994, projects included an "Equestri-Lift" for physically challenged equestrian riders and a "Wind Powered Generator."

As teacher candidates move through their community-based projects, discussion focuses on the transfer of their university experience into secondary school classrooms. They begin to think through what it means to act as facilitators. They begin to understand the connection between the notion of facilitator, the negotiation of meaningful student projects, and alternative ways to deliver course content (see Boomer, 1990). In the latter, the critical teacher skill is to be able to plan student learning of skills and knowledge to allow students to advance their community-based projects. Teacher candidates also discuss ways to weave values and human and environmental concerns into classroom talk and to provide a learning environment for secondary school technological education students that fosters creativity, exploration, critical thinking, and connections to what is learned in other school subjects and to life beyond school.

Conclusion

Research about school and community cooperation to deliver technological education programs at both secondary school and teacher education levels in Ontario, Canada, has documented that such collaborative classroom practice is not only possible in technological education, but is highly desirable because many modern theories of learning are seen in this educational practice (Hill & Smith, 1998). Collaboration between schools and community partners augments both secondary and university student learning and allows business and industry to give something back to the community from which they benefit.

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References

Boomer, G. (1990). Empowering students. In M. Brubacher, R. Payne, & K. Rickett (Eds.), *Perspectives on small group learning: Theory and practice* (pp. 42-51). Oakville, Ontario, Canada: Rubicon.

Dave, R. H. (Ed.). (1976). *Foundations of lifelong learning.* Oxford, United Kingdom: Pergamon Press.

Dewey, J. (1977). *Experience and education* (20th printing). New York: MacMillan Collier.

Dryden, K. (1986). *Report of the Ontario youth commissioner.* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Gubbels, A. A. (1995, April 25). Machine aids stroke victims: Graduating students develop device. *The Kingston Whig Standard,* p. 10.

Hill, A. M. (1996). *Relevant learning in technology education: A community-based project approach.* Paper presented to the Curriculum Studies Department, Faculty of Education, The University of British Columbia.

Hill, A. M. (1997). *Community projects in technology education.* Paper presented to the School of Graduate Studies, Faculty of Education, Monash University.

Hill, A. M. (1998). Problem solving in real-life contexts: Alternatives for design in technology education. *International Journal of Technology and Design Education, 8*(3), 203-220.

Hill, A. M. (1999). Community-based projects in technology education: An approach for relevant learning. In W. E. Theuerkauf & M. J. Dyrenfurth (Eds.), *International perspectives on technological education: Outcomes and futures* (pp. 285-298). Braunschweig, Germany: Braunschweig/Ames.

Hill, A. M., & Hopkins, D. (1999). University/school collaboration in teacher education. In M. Lang, J. Olson, H. Hansen, & W. Bunder (Eds.), *Changing schools/changing practices: Perspectives on educational reform and teacher professionalism* (pp. 171-182). Louvain, France: Garant.

Hill, A. M., & Smith, H. A. (1998). Practice meets theory in technological education: A case of authentic learning in the high school setting. *Journal of Technology Education, 9*(1), 29-41.

Human Resources Development Canada. (1994). *Improving social security in Canada. A discussion paper.* Hull, Quebec, Canada: Minister of Supply and Services.

Human Resources Development Canada. (1995). *Ontario's occupational prospects (1995 to 1997).* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Ontario Ministry of Education and Training. (1995). *Broad-based technological education. Grades 10, 11, and 12.* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Ontario Ministry of Education. (2000). *The Ontario curriculum. Grades 11 and 12. Technological education.* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Premier's Council. (1994). *Yours, mine and ours: Ontario's children and youth. Phase One* (Report of the Steering Committee of the Children and Youth Project to the Premier's Council on Health, Well-Being and Social Justice). Toronto, Ontario, Canada: Queen's Printer for Ontario.

Royal Commission on Learning. (1994a). *For the love of learning. Vol. I. Mandate, context, issues.* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Royal Commission on Learning. (1994b). *For the love of learning. A short version.* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Royal Commission on Learning. (1994c). *For the love of learning. Vol. II. Learning: Our vision for schools.* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Royal Commission on Learning. (1994d). *For the love of learning. Vol. III. The educators.* Toronto, Ontario, Canada: Queen's Printer for Ontario.

Ruddick, J. (1999). Teacher practice and the student voice. In M. Lang, J. Olson, H. Hansen, & W. Bunder (Eds.), *Changing schools/changing practices: Perspectives on educational reform and teacher professionalism* (pp. 41-54). Louvain, France: Garant.

Notes

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[2] An earlier version of this paper was presented to the International Conference of Scholars on Technology Education, Technische Universitat Braunschweig, Braunschweig, Germany, September 24-27, 2000.

Distance Education for Technology Teachers

By P. John Williams

This article describes a distance education approach that has been developed and implemented in Mauritius, Seychelles, and Botswana to help overcome limited teacher training opportunities and so help meet the demand for well-qualified technology teachers. It outlines the principles of course design, the mixed mode of delivery, and some of the issues of course delivery derived from program evaluations.

Technology in its current form is a relatively new subject; it has a brief history in schools as a component of general education (deVries, 1993; Layton, 1993). In some countries it has derived from vocational programs such as in Taiwan and Australia, and in others it is influenced by craft subjects such as in Sweden. Traditional technology education has also generally been gender biased, with activities designed to reflect gender stereotypes. The new technology education is moving away from narrow vocational preparedness and from gender specificity. The culture of school technology identified in the early 1990s (Layton, 1993; Puk, 1993) is developing, though still in its infancy, into a new paradigm about values, practices, content, methodologies, and capability (Kimbell, 2003).

The developing patterns of technology education in many countries challenge some of the traditional characteristics of schooling such as the decontextualization of knowledge, the primacy of the theoretical and secondment of the practical, and the organization of the curriculum along disciplinary lines. In contrast, technology education emphasizes the context of the technological activity, learning is achieved through the interaction of theory and practice, and it is interdisciplinary.

Some of the trends in technology education, which are obvious in a number of countries, include a movement from:

- Teacher as information giver to teacher as facilitator of learning.
- Teacher-controlled learning to teacher-learner partnership.
- Teacher-centered learning to student-centered learning.
- Time, age, and group constraints to individualized learning.
- Materials-based organization to needs-based activity.
- Product-centered to process-centered.
- Elective area of study to a core subject.
- Social irrelevance to socially contextualized.

Within the context of these trends, there is also a great degree of diversity throughout the world in technology education (Williams, 1996b). This diversity ranges from the absence of technology education in Japan (Elliot, 1990) to its compulsory study by all students in Israel (Israel Ministry of Education, Culture and Sport, 1996), an instrumentalist approach in Finland (Kananoja, 1996) to a basically humanistic approach in Scotland (Birnie & Dewhurst, 1993), a focus on content in the United States to a focus on the process in the United Kingdom, an economic rationalist philosophy in Botswana

Table 1. Comparison of the World's Population in Terms of Availability of Computers and Phone Lines

Category of Country	% of World Population	PC's/1000	PL's/1000
Low Income	40%	4	27
High Income	14.9%	346	583

Source: (World Bank, 2000).

(Molwane, 1993) and China (Wu, 1991) to a more liberal philosophy of science-technology-society in the United States (Layton, 1988), a staged and well-supported implementation of change as proposed in South Africa (Ankiewicz, 1993) to a rushed and largely unsuccessful implementation in England (McCormick, 1993), integrated with other subjects such as science in Israel, or as a discrete subject in Australia (Williams, 1996a).

Both the commonalities and the diversity are appropriate. The type of technology education developed within a country must be designed to serve that country's needs and build upon the unique history of technical education, resulting in a unique technology education program. This uniqueness challenges some of the notions related to the internationalization of the curriculum, particularly in the area of technology education. Other more traditional disciplines have developed an internationally acceptable body of knowledge, but technology has not and probably never will because of its variable historical significance and the diverse needs of different cultures.

Forms of Distance Education

A typical definition of distance education is the delivery of instruction in a format that separates the teacher and learner, often both in time and space (Keegan, 1980). It tends to be an umbrella term that may encompass more specific forms of education such as distributed learning, independent study, correspondence education, satellite education, etc. The focus of this discussion is text-based distance education, supplemented by intensive face-to-face sessions.

The factors contributing to good quality education are considered to be the same regardless of the mode of delivery, the country, or the setting. This is because of the "no significant difference" phenomenon associated with distance education research (Frost, 1998). The key variables are the quality of content and the support provided for the students, not the technology (Eastmond, 2000). "People learn as well from traditional print based correspondence courses as they do from the most slickly produced and/or interactive telecourses" (Russell, 1997, p. 6). If not designed and delivered well, distance education, of whatever mode, will only exacerbate poor quality instruction and compound already existing educational problems.

It is difficult to find current research about print-based distance technology education, this having been overtaken by online and Internet modes of delivery. Of the 558 articles on technology education referenced by this researcher, and the 526 full-text online journals accessed through WilsonWeb, a number of searches revealed no research since 1990 on print-based distance technology education.

A comparison of this research emphasis on electronic forms of distance education with the state of the world's population in terms of computer availability, phone lines, and arguably that portion of the population in most need of education indicates a significant imbalance (see Table 1). In low-income countries (40% of the world's population) there is one computer for every 250 people; in high-income countries (14.9% of the population and generally the origin of online distance education) there is one computer for every three people. In low-income countries there is one telephone line for every 37 people; in high-income countries there is one for every two people. There are about 400 million computers in the world, and 300 million of them are owned by 15% of the world's population.

The United States and the former Soviet Union have 15% of the world's population but operate 50% of the geostationary satellites (World Bank, 2000).

It would seem plausible to conclude that the current direction of distance education research is not serving the interests of the majority of the population who need an education and are typically undereducated. This is compounded by the high proportion of untrained and unqualified teachers in low-income countries (Nielsen, 1997) and reinforced by the evaluation of distance education reported in this article.

Course Design

A teacher education course in technology education derives its content from three main sources. One is the educational system for which the teachers are being trained. Information from this source includes syllabi, methodologies, school contexts, etc. The second source is the technological activity that takes place in society, and the third source is from the discipline that is being studied, in this case technology education. The research and literature of the discipline gives guidance on content, structure, learning patterns, and methodologies.

All these systems are vital sources for the design of a teacher-training course in technology education. Graduates need to be suited to the system in which they are going to work, but their tertiary studies should be more than a repetition of the respective secondary syllabus at a deeper level.

Each course reported in this article was designed to accommodate the above characteristics in the context of the appropriate education system. This meant significant local input with regard to the local educational system and the social/technological context. It was found that it is difficult to do this at a distance and requires face-to-face negotiation. The core content and instructional methods were derived from existing units of study, which were then customized and contextualized to suit the specific environment. The background and learning styles of the students are also important to consider, and to some extent knowledge in this area develops as the course proceeds. This revision and sensitization process has been repeated each time the course has been offered, as it is not possible to internationalize a technology education curriculum to the extent that it is generalizable and relevant regardless of the country of implementation.

A guiding principle of the course is that students must learn how to learn. With technology changing as rapidly as it is currently, there is a limited life span in the skills students are now taught. Students must be taught how to independently develop new skills and how to find out about new materials, equipment, and systems. Then when the need later arises for personal professional development or for school development, teachers are well equipped for the task.

The contextual goal of the courses is also sustainable development within the country. This applies to individual teachers who, as a result of courses of study, will:

- develop relevant and current content knowledge in technology education;
- incorporate contemporary pedagogical skills into their teaching;
- be better equipped to guide the development of young students; and
- understand international best practice in technology curriculum development.

Typically, courses had to be designed quickly. The identification of a market opportunity was followed by the development and submission of a proposal to the key people in the market. A lengthy delay at this stage could have resulted in missed opportunities. The initial proposal was clearly identified as a flexible starting point for discussion and negotiation about the structure and content of the course, and then after a series of discussions and meetings, the specifics were modified and developed later.

Initial proposals were not specifically costed, but a range of delivery options were outlined, with an indication of the relative expense of each option. Sponsors do not necessarily choose the least financially expensive option, as other factors such as ease of administration and perceived quality of delivery are important factors. In one country the most expensive delivery option was selected because that was the traditional approach to upgrading teachers in that country.

If the market opportunity was identified by a person not connected with the coordination or delivery of the course, then it was found necessary for a person expert in the content of the course to visit the sponsors to negotiate the course details, answer questions, and develop an understanding of the environment in which the course would be delivered. Important information related to facilities and equipment, prior experience and education of the potential students, curriculum, cultural and regional considerations, and local coordinators.

As a result of these initial visits and communication, a specific and costed proposal and course design was developed and signed by the appropriate parties. Responsibilities of all involved were specifically detailed. This detail is essential and can significantly impact on course success. For example, in one course student consumables were the responsibility of the local sponsors. This proved to be a greater expense than was anticipated and would have impacted significantly on university revenues.

Course Delivery and Structure

The Design and Technology Bachelor of Education (Secondary) program is designed to prepare students to teach design and technology at all levels in the secondary school. The award is granted after the successful completion of four years of full-time study (or equivalent), that is 8 semesters at 4 units each semester, or 32 units. The remainder of the suite of undergraduate courses available in this area of D&T include a three-year Bachelor of Arts degree, a two-year Bachelor of Education upgrade for diploma holders, and a one-year Bachelor of Education upgrade for Bachelor of Arts degree holders. These are all subsets of the 32 units of the Bachelor of Education, which provides a pool of units from which to select the most appropriate for the specific market. So for example, the 16 units of a two-year Bachelor of Education upgrade offered in one country may be different from that offered in another because they are selected and matched to the specific needs of the market.

The courses are delivered through a combination of distance mode and intensive workshops/lectures over a period of up to four years. Students study part time, and enroll in two units per semester. The part-time study involves readings, assignments, assessment, and examinations being forwarded to the students in concert with a period of intensive lectures/workshops in their country. This provides about 30 hours of face-to-face interaction with the lecturer for each unit and is delivered in about the middle of each semester during the school holidays. So students do some study both before and after the on-site classes.

The advantages of this mode of delivery include:

- no disruption to schools through the absence of teachers;
- education activities, discussions, and applications can be grounded in current practice; and
- the opportunity for collaborative teaching and research between local staff and university lecturers.

The upgrade course consists of three types of units:

- Education Studies: studies in the theory of education, educational psychology, and teaching studies and practice.
- Curriculum Studies: studies of relevant curriculum resources and related teaching.
- Content Studies: appropriate specialization content.

The balance of these units varies depending on the local context and needs.

Some courses were proposed as a joint venture between the university and the local ministry of education (in the case of a sponsored cohort of students), with the provision of concurrent opportunities for postgraduate study (MEd or PhD) for local lecturers. This postgraduate study can be done by distance, and opportunities for supervision and guidance would arise through the undergraduate course activities. In some instances a fees-only postgraduate study scholarship for the top academic student has been provided upon completion of the course. Other courses were advertised and offered to teachers who then are responsible for their own fees.

Costs and Responsibilities

Generally, distance education incurs lower costs per student than traditional face-to-face education, often generated through economies of scale, but this is offset by large dropout and repetition rates. The UK Open University has a completion rate of 49% (200,000 students), 28% at the Indira Gandhi National Open University (431,000 students), and 10% at the Korean National Open University. Completion rates tend to be lower in less-developed countries as students in those contexts typically enroll in distance programs as a matter of necessity rather than from choice (Latchem, Abdullah, & Xinhfu, 1999). The completion rates for the courses described in this article vary from 90% to 100%.

For a specific program offered to a foreign government by a university, the criteria which form the basis of value-for-money decisions include the reputation of the university, the level of understanding of the delivery context, the flexibility of both content and mode of delivery options, fees, and politics.

In this situation the sponsor's responsibilities may include:

- nomination and resourcing of a locally based program coordinator;
- recruitment of the cohort of teachers into the program;
- the provision of an appropriate venue for the on-site teaching;
- funding time off for course participants, for example, one day/fortnight during semesters;
- the provision of consumables and technical support for the on-site teaching;
- organization and funding of mentors; and
- organization and invigilation of examinations.

The university's responsibilities may include:

- all costs associated with university or local staff conducting the in-country teaching;
- provision of all distance education materials;
- implementing enrollment and recording procedures;
- reasonable remediation of failing students;
- setting and marking assignments and examinations; and
- granting the relevant degree.

If the government sponsors the program, it is funded on the basis of a specific number of students being the minimum in the cohort. If the number of students drops below that level, the cost will be maintained. It is generally agreed that a specific number of students above that level can be enrolled for no extra cost. When individual students are paying their own fees, the university applies a formula of income and costs to determine course viability.

Issues

The following are some of the issues that have arisen from the delivery of distance technology education to technology teachers and the evaluation of those programs.

Level of Technology

Technology education in teacher training serves the dual role of modeling experiences and activities that teachers can implement in their schools when they begin teaching and experiences that enhance their understanding of technology. Both are important because teachers need starting points for their teaching, but also need a sophisticated awareness of the nature of technology. In extending educational experiences across cultures, the correct balance, and the justification of the balance between these two goals, is imperative. In-country experts and the students themselves can provide guidance on achieving this balance. The principles of appropriate technology become relevant in the selection of technological activities and the context of application of the processes of technology education.

In relationship to the mode of delivery, the instructional technology seems not to be a key variable for success. As Frost (1998) has pointed out, any socially just delivery system must ensure that we are not just servicing a small group of well-off elites. New and advanced technologies will expose traditional cultures to Western values and may create as many problems as it solves. Resulting unrealistic learning behaviors may cause distance education to be viewed as a cultural Trojan horse (Wennersten, 1997). So the level of technology must be at the same time socially equitable, challenging to the participants, and accessible.

Local Capacity Building

There is the recognition that as a result of each course, apart from having better qualified graduates, more local capacity to deliver the course in the future should be developed. The experience has been that unless such capacity building is detailed in the initial contract, it is very difficult to develop during the project. People are very busy, and unless there is some compulsion to undertake additional tasks, despite any long-term advantage that may accrue, opportunities will not be taken up.

The type of collaboration necessary to achieve this end brings with it a number of dangers. One is the danger of cultural imperialism, which is difficult to resist when the visiting lecturers are presented as the international experts. The other danger is the "trendy" aspect of collaboration. "Too often alliances are cobbled together for the purposes of proposal submission. Alliances without 'roots,' without an investment in partnership development, will limit the potential for success of projects" (Gerhard, 1997, p. 3).

Facilities

In some countries the facilities are not available to offer units that would normally be considered core units. For example, in technology education these could relate to computer-assisted drawing and machining, advanced materials, electronics, and a range of computer-based units. In some countries these units cannot be offered; in others the unit content can be modified to enable it to be offered in an appropriately contextualized way, for example, with the use of share-ware software rather than expensive commercially produced packages or with local experts discussing local technologies.

Local Politics

There is invariably a political dimension involved in the context in which the course is delivered. A local course coordinator is invaluable in steering through the potential pitfalls of teaching site selection and dealing with local institutions and authorities, which may respond to a variety of agendas. This can nevertheless be a source of frustration as the sense of urgency felt at the source institution about material availability, for example, is not always replicated in going through the protocols in the local delivery context.

Lecturers

It takes some time interacting with a class for a lecturer to develop a rapport with students, and when they spend 30 hours together over one or two weeks, the relationship seems to become quite strong. Students do not want to go through this "getting to know the lecturer" period with a new lecturer for every unit. However, if the "expert" in each unit is the person sent to do the teaching, then many different people are involved in a course. It has been necessary at times to restrict the number of people involved in course delivery in order to help ensure student comfort.

In instances where it is appropriate to localize course material, a local expert may be involved in presenting to the students. This can, however, be perceived negatively by the students, who consider they are paying for an overseas course and that is what they want, not local lecturers.

Currency

Currency restrictions may inhibit the ability of students to purchase course material. This can occur at both personal and national levels if there is close monitoring of the country's foreign currency reserves. This has been overcome at times by selling resources in local currency to the students and then using that income for local expenses of the project, but still may result in curtailing the resources available to students.

Course Duration

Some of the students have been dissatisfied with the duration of their course. They would have preferred, for example, to study for three semesters per year and complete a two-year full-time course in under three years part time than to study for two semesters each year over four years. This more intensive mode of delivery places increased pressure on the source institution and may result in negative consequences on other aspects of departmental activity.

Communication

Because standard means of communication such as mail, Internet, and fax can be unreliable or nonexistent, communication with both students and coordinators in the host country can be frustrating. Typically, some students have Internet connections, and mail and fax are unreliable. This means forward planning is critical, and normal processes may sometimes need to be circumvented. For example, an unreliable mail system resulted in a batch of exam papers going missing and alternative strategies had to be devised; and assignments, both to and from students, are express mailed together to a central location rather than to individual students.

Conclusion

For many students, text-based distance education represents their only source of educational opportunity. In the area of technology education, a successful mode of delivery incorporates a period of intensive face-to-face interaction with a lecturer. Detailed planning and the contextualization of both content and methodology is vital, but flexibility in the implementation of those plans is just as important in order to overcome unforeseen barriers. Key variables for success include high-quality content, appropriate methods, and student support to enable them to effectively utilize new knowledge.

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References

Ankiewicz, P. (1993, September). *Aspects of planning of technology education for South African schools.* Paper presented at the IDATER'93 Conference, Loughborough, United Kingdom.

Birnie, T., & Dewhurst, Y. (1993, April). *Profiling technology within the Scottish environment.* Paper presented at the PATT6 Conference, Eindhoven, the Netherlands.

de Vries, M. (1993). Technology education in the Netherlands. In R. McCormick & Others (Eds.), *Teaching and learning technology* (pp. 28-38). Wokingham, United Kingdom: Addison Wesley.

Eastmond, D. (2000). Realizing the promise of distance education in low technology countries. *Educational Technology Research and Development, 48*(2), 100-111.

Elliot, P. (1990, September). *Study tour of Japan.* Paper presented at the IDES 90 Conference, Edinburgh, Scotland.

Frost, C. H. (1998). Distance education for developing countries. *International Education, 27*(2), 56-67.

Gerhard, W. J. (1997). *The care and feeding of partnerships.* Paper presented at the 18th International Council for Distance Education Conference, Harrisburg, PA.

Israel Ministry of Education, Culture and Sport. (1996). *Technology education in Israel.* Tel Aviv, Israel: Amal Pedagogical-Technological Center.

Kananoja, T. (1996). *The situation in Finnish technology education in 1995-1996.* Unpublished paper, Oulu University, Finland.

Keegan, D. J. (1980). On defining distance education. *Distance Education, 1*(1), 13-36.

Kimbell, R. (2003). Reflections on the DATA Conference paradigm debate. *The Journal of Design and Technology Education, 8*(1), 12-17.

Layton, D. (1988). Revaluating the T in STS. *International Journal of Science Education, 10*(4), 373-378.

Layton, D. (1993). *Technology's challenge to science education.* Milton Keynes, United Kingdom: Open University Press.

Latchem, C., Abdullah, S., & Xinhfu, D. (1999). Open and dual-mode universities in east and south east Asia. *Performance Improvement Quarterly, 12*(2), 96-121.

McCormick, R. (1993). Technology education in the UK. In R. McCormick & Others (Eds.), *Teaching and learning technology* (pp. 15-27). London: Addison Wesley.

Molwane, O. (1993, September). *Developing technology education in Botswana.* Paper presented at the IDATER'93 Conference, Loughborough, United Kingdom.

Nielsen, H. D. (1997). Quality assessment and quality assurance in distance teacher education. *Distance Education, 18*(2), 284-317.

Puk, T. (1993). The acculturation of technology education. *The Technology Teacher, 52*(7), 27-30.

Russell, T. L. (1997). *The international implications of the videoclass system.* Paper presented at the 18th International Council for Distance Education Conference, Harrisburg, PA.

Wennersten, J. R. (1997). *Distance education and underdeveloped nations: Global learning or global baloney?* Paper presented at the18th International Council for Distance Education Conference, Harrisburg, PA.

Williams, P. J. (1996a, January). *Australian national technology education project.* Paper presented at the Second Jerusalem International Science and Technology Education Conference, Jerusalem, Israel.

Williams, P. J. (1996b). International approaches to technology education. In P. J. Williams & A. P. Williams (Eds.), *Technology education for teachers* (pp. 266-290). Melbourne, Australia: Macmillan.

World Bank. (2000). Data and maps. Retrieved from http://www.worldbank.int/data/

Wu, X. (1991). The potential for technology education in People's Republic of China. *Journal of Technology Education, 3*(1), 70-76.

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Databases Improve Technical Studies

By Gabriele Graube

Target

In Lower Saxony, technology studies as part of preparing technical education teachers for primary and partly for secondary education can be studied only at two universities—the Technical University of Brunswick and the University of Oldenburg. Technology education is not available at the Gymnasium (a type of secondary school leading to the university) in Lower Saxony.

Universities in Lower Saxony and other German states have agreed about the basic contents of technology education that should be taught in the public schools. However, the themes are emphasized differently, because the universities view the subject and conduct their research differently from one another.

The target is to connect the technical resources of the participant universities to reveal the variety of contents of the subject and to allow access to sources of knowledge irrespective of time and place. Specifically, the creation of accessible databases for technology education via the Internet will help educators teach technology as thoroughly as possible and offer the opportunity to reach larger numbers of students at colleges and universities. A further step will be to connect the databases of individual partner universities to a database network.

The technology education database is meant to represent an important scientific and didactic source for the subject *technology.* Our further intention is to include the latest results of research, including that gained from national and international technical learning processes, and to maintain teachers' educational experiences in the form of evaluated teaching samples. We plan to include proven samples of lessons that have been tested by teachers, lecturers, and students as "methodical patterns" that can be used subsequently by other students and lecturers.

The technology education database will help students to fulfill the following tasks during their studies (Dick, 2000; Scheuermann, Schwab, & Augenstein 1998):

- Acquire and select specific information for special themes.
- Prepare papers and work on scientific reports.
- Prepare and rework lectures.
- Study the contents of technology education irrespective of the place of studies and the type of school.
- Study as independently as possible.

Lecturers will get support to fulfill their educational tasks:

- Compile and work with technical literature.
- Select adequate educational material, either discrete (texts, pictures) or continuous (video, audio, simulations, animations).

Advantages of the Technology Education Database

The technology education database has several advantages. It will:

- Create a source of knowledge concerning technology education at universities and public schools.
- Ensure efficient presentation of the interdisciplinary structure and the variety of contents of the subject and its various media and methods.
- Have flexible application of the database's modules (applicable in a new context, adjustment of contents, application regardless of time).
- Allow students and lecturers to have access to the database via the Internet irrespective of time and place to plan studies independently or to prepare lectures.
- Enable national and international exchange of knowledge and experience between universities.
- Promote self-learning.
- Develop competence with regard to media and information.
- Awaken the interest of females in technology education by offering easy access to knowledge.
- Enable worldwide distribution of educational material.
- Facilitate students' transfers between institutions not only within one federal state but all over Germany, as certificates

are mutually accepted.
- Facilitate installation of a course of study for Europe or overseas (medium-term and long-term plans).

Contents of the Technology Education Database

The contents of the technology education database are closely related to the courses of study of the university. Although courses of study differ from university to university, the fields of study are identical in most cases. The content of the fields of study is focused on technological processes and systems that are categorized by material, energy, and information.

The courses of study include not only special scientific fields, but also special didactic fields that students must study. Usually the contents are taught in the form of lectures, seminars, exercises, and practical training in laboratories and workshops. As a target of the database network, the fields of study will be enhanced by the multimedia teaching and learning modules of the technology education database.

If it is possible to update lectures and to give them a personal note, then the content will have to be split into modules. The modules can then be used in different types of lectures and can be combined and completed in such a way that they meet the requirements of the individual courses of study.

The fields of study for the database must be selected. The modules have to be of special importance for the studies and, therefore, for the future professional work of a technology teacher. Thus, the modules to be developed should have a key function and students must master them through examinations.

In the first phase of this database network development, the University of Essen and the Universities of Brunswick and Oldenburg will create databases in their special fields. The Institute for Technology and Technical Didactics of the University of Essen plans to create modules for the following fields of study: materials science, energy technology, measurement, open-loop control, closed-loop control, and environment protection. The Department of Technology Pedagogics of the Technical University of Brunswick and the Institute for Technology Education of the University of Oldenburg intend to create modules for the following fields of study: manufacturing engineering, information and communication technology, and didactics of the subject technology.

In Essen as well as in Brunswick the first modules and experiences already exist. The Institute for Technology and Technical Didactics of the University of Essen has created the first modules during a project, Component-Based Learning Software for the Training of Teachers, sponsored by the federal state of Nordrhein-Westfalen (http://it.tud.uni-essen.de). During the summer semester 2000, the Department of Technology Pedagogics of the University of Brunswick tested the application of an Internet module, Creation and Application of Websites for Learning Processes.

The modules may include exercises, examples of lectures, complete training programs, and single components. They are categorized and stored according to criteria that are important to the courses of study. Texts, graphics, animations, and videos as well as simulations, virtual tests, virtual laboratories, and case studies will be included in the modules. The possibility of authentically presenting complex technological/scientific matters is a project target that can be reached with the help of multimedia visualization.

One example is an ActiveX-Component, showing the characteristic of a feedback control unit based on an operational amplifier, which serves as a laboratory test. Video clips are intended to be used for the visualization of manufacturing processes to support the practical part of the studies (Schweres, Redeker, Theuerkauf, Balzer, & Rummel 1998). Videos will also be used for case studies that evaluate technology.

The individual databases of the network are being developed so that the contents of each are complementary. This process will take a longer period of time. The databases located at the universities will be dynamic. They require ongoing maintenance to remain current and thus require a new form of cooperation between the partner universities.

Practical Realization

It must be ensured that the database is accessible at any time and from any place. To meet these requirements, the modules and the components of the database will be accessible via the Internet using Netscape or Internet Explorer. However, a prerequisite for this is that the didactically shaped modules are prepared in such a way to allow Internet capability.

Thus, new and existing knowledge must be structured, shaped, and transformed with respect to the rules of multimedia learning environments. This means that they have to be transformed into Internet formats (HTML, ActiveX, Java, JavaScript, etc.). This requirement is also necessary for the components of the individual modules. Texts must be formatted as xxx.pdf/rtf, graphics/pictures as xxx.jpg/gif/png, and videos as yy.mpg.

All files will be stored with their source code and documentation in databases running on Web servers of the universities.

As an example, the database will be installed on the computing center’s dataserver of the Technical University of Brunswick. For this purpose, a determined storage capacity with defined access authority is at the user’s disposal.

Learning Arrangement

With the database, lecturers have a source of the most up-to-date scientific and didactic contents including an address collection of Internet sources that enables them to use new methods for teaching. The components and modules can be used by the lecturer to demonstrate technological matters in lectures/exercises/tutorials. The lecturers can organize their courses without restrictions concerning contents and methods. The modules, which are independent concerning the contents and which can be combined variably, represent a source of information for courses, exercises, and projects.

However, technological processes, systems, and virtual laboratories can be visualized more authentically with simulations than with conventional media (Fäßler, 2000). Knowledge about the relationship of technological processes and systems can be obtained with the help of simulations.

With the database`s contents structured according to didactical aspects, students can acquire information for a chosen or given theme for an exercise, a laboratory test, a task, or a project. As an example, components of the database can be included in one’s own work. The acquisition and evaluation of information will get more and more important, particularly regarding technical competence.

The database supports independent study, so that the themes of the courses can be expanded and completed. At the same time, students achieve media competence with respect to selection and evaluation of information as well as with the creation of new or improved modules during seminars or exams. Afterwards, these modules can be stored into the database, too. A module that helps to create Web sites will be the basis to transform teaching and learning methods so that it can be used on the Internet.

Partners of the Database Network

Internet-based studies and further education courses already exist on national and international levels. Designing the database without restrictions calls upon us to use experiences and developments of the special fields of other universities that are involved in the courses of study for technology educators and that also use multimedia in teaching.

Partners for this project among the federal states of Germany are the Department of Technology Pedagogics of the Institute for Scientific Didactics of the Technical University of Brunswick and the Institute for Technology Education of the University of Oldenburg. Other partners of the database network are the Institute for Technology and Technical Didactics of the University of Essen and the Institute for Technology and their Didactics of the University of Dortmund, which is responsible for the subject technology in secondary schools. The Institute for Vocational Education of the University of Rostock, which trains teachers for electrical engineering at vocational colleges, has announced its partnership, too. These partners ensure that in Germany the different courses of study for technology education in primary and secondary schools and in vocational schools are represented appropriately.

Due to the international interest in an exchange of training modules, a continuation project to enlarge the database network will follow in cooperation with partners, such as the University of Marseille, the University of London, and the Chilean Ministry of Culture. This database network can be seen as an important global source and as a forum for technology education. This step seems to be reasonable to internationalize the course of studies for technology education as it exists in other nations, too.

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References

Dick, E. (2000). *Multimediale lernprogramme und telematische lernarrangements* [Multimedia learning programs and distance learning]. Nürnberg, Germany: Bildung und Wissen Verlag and Software GmbH.

Fäßler, V. B. (2000). *Entwicklungen vonsSimulationen für technische lernprozesse* [Development of simulations for technical learning processes]. New York: Peter Lang.

Scheuermann, F., Schwab, F., & Augenstein, H. (1998). *Studieren und weiterbilden mit multimedia* [Study and further education with multimedia]. Nürnberg, Germany: Bildung und Wissen Verlag and Software GmbH.

Schweres, M., Redeker G., Theuerkauf, W. E., Balzer, H.-J., & Rummel, J. (1998). *Anwendergerechte unterstützung durch multimediatechnik im produktionsbereich* [Application support via multimedia technology in production]. In H-J. Franke & T. Pfeifer, *Qualitäts informations system.* [Quality information systems]. Münich, Germany: Hanser.

Strategies for Reforming Workforce Preparation Programs in Europe

By Marja-Leena Stenström and Johanna Lasonen

The SPES-NET Project

The Post-16 Strategies project coordinated by Dr. Johanna Lasonen from 1996 to 1998 was chiefly concerned with four post-16 education strategies: *vocational enhancement, mutual enrichment, linkages,* and *unification.* These four strategies to promote parity of esteem between vocational and academic/general education were also seen as tools for analyzing the differences and similarities between the reform approaches adopted in the eight European countries (Austria, England, Finland, France, Germany, Norway, Scotland, and Sweden) associated with the first project (Lasonen, 1996, 1999).

The strategy of *vocational enhancement* entails reforming the content of vocational education and training separately from general/academic education. Esteem for vocational education is assumed to be linked with the standard of the content offered and the pedagogy applied in vocational education and training.

In the strategy of *mutual enrichment,* the aim is to cooperate across the divide between general and vocational education and to give students in each track a wider range of options by drawing on the best features of the other track. The two types of education are brought closer to each other but retain their distinctive character.

In the *linkages* strategy, vocational and general/academic education are given the same formal status and linked through a common certification framework. Both types of education guarantee qualification for further and higher education, and earlier studies are recognized irrespective of track.

In *unification,* the distinction between vocational and general education is abolished by combining them within a unified system and developing a curriculum that integrates the two types of education.

The first three strategies aim to maintain a separate identity for vocational and general education. By contrast, the fourth strategy seeks to combine them into a uniform upper secondary education system (Lasonen, 1999).

SPES-NET (Sharpening Post-16 Education Strategies by Horizontal and Vertical Networking) known as the Leonardo da Vinci project, continued the work of the Post-16 Strategies project. Lasonen also launched and Stenström coordinated the SPES-NET project that was funded by the European Commission, the Finnish Ministry of Education, and the project partners, and that ran from 1997 to 2000. It focused on reanalyzing and exploiting the four hypothetically identified reform strategies intended to promote parity of esteem between general and vocational education in upper secondary education.

Aims of the Project

The SPES-NET project focused on promoting vocational education and training in the partner countries, which increased from the original eight countries in the first project to 13 nations in this project. An initial objective of the Post-16 Strategies project was to find ways of improving the status and attractiveness of vocational education and training.
The aims of the succeeding project, SPES-NET, were to:

- Find ways to improve the status of vocational education and training.
- Find ways to forge links between educational establishments and enterprises.
- Disseminate the results of the Post-16 Strategies project.
- Define dissemination activities intended to create national and international networks.

Table 1. Partner Institutions: Type of Institution

Type of Institution	New Partners	Old Partners
Research institute		England France Austria
University department	Spain Greece Hungary	Germany
Further education college		Scotland
Teacher training establishment	Denmark	Norway
Administrative agency	Estonia	Finland
Consultancy and training establishment	Belgium	

Since the partnership had been extended to southern and eastern Europe, it became possible to evaluate the four previously identified post-16 education strategies in a new context. The project also tried to find ways to develop links between education and work as an important method for improving the status of vocational education.

The Partnership

The partnership brought together 14 institutions from 13 European countries including the new partners from eastern and southern Europe (see Table 1). Some partners represented researchers and others the context of practitioners. The SPES-NET project was carried out by a multicultural team representing researchers, policymakers, administrators, and teacher educators. The methods used were calculated to promote mutual understanding and shared solutions while also producing cross-national knowledge of ways to improve the quality of initial vocational education. The workshops featured presentations of data and syntheses, roundtable discussions, and brainstorming sessions. Conclusions pertaining to separate nations were drawn as were comparisons. The results of the comparisons were disseminated in each partner country (Stenström & Lasonen, 2000).

The range of different backgrounds of the representatives made for a fruitful environment for a dissemination project. The interdisciplinary nature of the project was considered a

Table 2. Educational Reform Strategies

Strategies by countries / *Substrategies*	*1. Vocational enhancement* Germany Austria Denmark*	*2. Mutual enrichment* Finland Norway	*3. Linkages* England France Spain*	*4. Unification* Scotland Sweden
1. Improving links with higher education (HE)	Reforming and expanding vocational HE	(i) Improving access to existing HE (ii) Creating a new vocational HE system		Creating a single system of post-compulsory education
2. Improving links with employers	Strengthening dual-system partnerships	Strengthening partnerships between providers of VET and employers		Strengthening links between employers and vocational and general education teachers
3. Raising the status and qualifications of vocational teachers and trainers	Equalizing the status of vocational and general education teachers	Providing some common courses for vocational and general education teachers		Common training and qualifications for general education and vocational teachers
4. Improving the VET curriculum	Improving the vocational education component	More general education on vocational programs		More integrated learning

*New partner
Sources: Lasonen, 1996; Young, 2000.

positive feature because it created bridges to shared understanding between different countries in Europe. This multidisciplinary, multicultural approach produced a range of different solutions to the problems of vocational education and training (Lasonen, 1998; Stenström, 2000).

The SPES-NET project undertook a reanalysis of the previously identified reform strategies, proceeding through the following stages:

1. Analyzing the four post-16 education strategies in a new context.
   - Preparing and analyzing case studies of the new partner countries.
2. Reflecting on the post-16 education strategies.
   - Fitting the new partner countries' reforms into the framework of the four post-16 education strategies.
3. Developing a framework paper on new substrategies for the previously defined four post-16 education strategies.
   - Preparing a final summary of the substrategies on the basis of the partners' responses to an earlier draft of the framework paper, which was prepared by the English partner (Young, 2000).
4. Surveying the progress of forming links between educational establishments and enterprises.
   - Preparing a framework paper on education-work relationships (Marhuenda, 2000).
   - Case studies of the partner countries.

Reflections on Post-16 Education Strategies

It was not easy to classify educational systems in terms of the four post-16 education strategies. The four hypothetical reform strategies of the Post-16 Strategies project revealed that contexts existing in northern, western, and central European countries made the comparisons complicated. Extending this analysis to other regions was particularly difficult in the case of countries undergoing structural and political changes, such as Estonia and Hungary, and in the case of countries such as Estonia and Greece, where vocational secondary education is not well developed (Stenström, 1999).

The question the SPES-NET project faced was whether the previously defined four post-16 education strategies were relevant to the new partners or whether a model that included a strategy for academic track separate from vocational and a strategy where they are unified should be adopted instead. However, it was decided to retain the original typology but shift the focus of the comparisons to improvements in the quality of vocational education. Out of the larger context provided by the 13 European partners a new conceptual framework of strategies and trends emerged. It was clear that reform strategies must be defined in a more precise manner, distinguishing between the different substrategies for improving vocational education and its status relative to general education as follows (Stenström & Lasonen, 2000; Young, 2000):

- Improving progression to higher education by students in vocational programs.
- Improving progression into employment by students in vocational programs.
- Improving the status and qualifications of vocational teachers.
- Improving the vocational and general components of the vocational education curriculum.

These substrategies were used for comparing reforms launched in different countries to improve vocational education.

In Table 2, the horizontal axis is represented by the four strategies that were identified in the original Post-16 Strategies project. The vertical axis is the four substrategies for improving vocational education that were identified in the SPES-NET project. The matrix shows the relation between strategy (as context) and substrategy (as content). The partly hypothetical options presented in the matrix indicate the existence of three types of reform strategy because the matrix combines two of the previously defined four strategies, mutual enrichment and linkages.

All partner countries had reported some developments definable in terms of the four substrategies. The substrategy of improving progression opportunities into higher education for vocational education students seems to be the easiest one to adopt. The substrategy of improving the status and qualifications of vocational teachers is difficult, especially in those countries in which salary differentials between private and public sectors remain large. Finally, improving the vocational curriculum depends on administration, teaching, and teacher education and on cooperative links between employers and vocational education providers. The relationships between education and working life is one of the key questions involved in attempts to improve the quality of vocational education and training.

The SPES-NET project *focused* exclusively on *internal strategies* for improving vocational education and training, ignoring external strategies. Such external strategies as interventions in labor markets might affect the status of vocational education and training and the issue of parity of esteem.

The SPES-NET project also *concentrated* on differences between national systems and national strategies for improving the quality of vocational education and parity of esteem between vocational and general education as they are manifested *at the policy level.* It was not concerned with new curricula and pedagogies. However, moving from the level of strategy to the level of specific curriculum and pedagogic initiatives would be a valuable topic for further research (Young & Volanen, 2000).

The partner countries face a number of common problems despite having very different educational systems. These common issues relate to ways in which attempts to improve vocational education continue to be hampered by the persistence of academic/vocational divisions in the curriculum. First, there is academic drift or the tendency to encourage students to opt for academic programs. Second, there is the concern expressed by both employers and vocational teachers about the poor quality and lack of motivation of students in vocational programs. Third, academic/vocational divisions are inhibiting the development of new types of vocational programs for the 21st century.

Despite the differences in how the sub-strategies are interpreted in different countries, some common trans-European trends did emerge. These are summarized as:

- More standardization of qualifications for students and teachers.
- Greater emphasis on work-based learning and the educational potential of workplaces.
- Efforts to increase employer involvement in all aspects of vocational education and training provision.
- More choices for students and more autonomy to localities and individual institutions.

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References

Lasonen, J. (Ed.). (1996). *Reforming upper secondary education in Europe: The Leonardo da Vinci project post-16 strategies* (Theory Into Practice No. 92). Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Lasonen, J. (1998). Finding new strategies for post-16 education to promote parity of esteem between vocational and general education. In A. Dietzen & M. Kuhn (Eds.), *Building a European co-operative research tradition in vocational education and training* (pp. 85-95). Berlin, Germany: BIBB, Bundesinstitut für Berufsbildung.

Lasonen, J. (1999). Sharpening post-16 education strategies: Building on the results of the previous projects. In M.-L. Stenström (Ed.), *Reflections on post-16 strategies in European countries: Sharpening post-16 education strategies by horizontal and vertical networking* (Working Papers No. 9, pp. 9–22). Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Marhuenda, F. (2000). Rethinking education-work relationships. In M-L. Stenström & J. Lasonen (Eds.), *Strategies for reforming initial vocational education and training in Europe* (pp. 239–249). Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Stenström, M.-L. (1999). Reflections on disseminating strategies for reforming post-16 education. In M.-L. Stenström (Ed.), *Reflections on post-16 strategies in European countries: Sharpening post-16 education strategies by horizontal and vertical networking* (Working Papers No. 9, pp. 159–168). Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Stenström, M.-L. (2000). Reassessing VET reform strategies in a new context: Implementation of the SPES-NET project. In M.-L. Stenström & J. Lasonen (Eds.), *Strategies for reforming initial vocational education and training in Europe* (pp. 15–28). Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Stenström, M.-L., & Lasonen, J. (Eds.). (2000). *Strategies for reforming initial vocational education and training in Europe.* Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Young, M. (2000). Improving vocational education: Trans-European comparisons of developments in the late 1990s. In M.-L. Stenström & J. Lasonen (Eds.), *Strategies for reforming initial vocational education and training in Europe* (pp. 147–162). Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Young, M., & Volanen, M. V. (2000). Towards a vocational curriculum and pedagogy of the future: Taking the post-16 education strategies and SPES-NET project findings forward for future research. In M.-L. Stenström & J. Lasonen (Eds.), *Strategies for reforming initial vocational education and training in Europe* (pp. 258–279). Jyväskylä, Finland: University of Jyväskylä, Institute for Educational Research.

Relation of Technology, Science, Self-Concept, Interest, and Gender

By Ingeborg Wender

The Need for Promotion of Women in Science and Technology

For nearly 20 years the topic of “women and technology” has played an important role in discussions about gender equality in Germany. The very first project for promoting females started in 1978 under the title “Women in Male Occupations.” It was initiated by the Federal Ministry of Education and Science and was aimed at vocational-technical levels. Soon a variety of projects followed, financially supported by the Federal and District Commission for Educational Planning and Promotion of Research and by the individual governments of the various districts (Ostendorf, 1994).

The initial incentive to develop such projects was the fact that women were highly under-represented in educational fields of technology and in those related to technology. Increasing the number of women in technology and science was a political goal. Consequently, many actions were initiated to increase women's participation in schools, universities, and/or extracurricular fields. Currently, special attention is being paid to specific subjects such as computer science and computer technology. The reason for this is the current lack of experts in these fields.

Despite the important role of technology in society, it is seldom taught in schools. That was not the case in the former Federal Republic of Germany. A special polytechnical teaching existed in schools; unfortunately, it was given up after the reunion. Therefore, we have an obvious deficit in Germany.

Because the proportion of students in natural, computer, and technological sciences has sunk dramatically in general, there are now various educational programs to increase the attractiveness of these subject areas. Most prominently, colleges and research institutions advertise intensively and offer their research resources to teachers and pupils. The best examples are the Göttinger Experimental Laboratory for young people (XLAB of the University of Göttingen), which concentrates on natural science, and the DLRSchoolLab of the German Center for Aeronautics and Space Travel in Göttingen, where aerodynamics is stressed. Almost all technical colleges offer pupils a day or a week of open house, including experiments and special projects. Pupils aged 15 to 20 are the main target group of these activities.

Because of the well-institutionalized promotion of women at colleges, a diverse science and technology campaign was developed, which has acted as a forerunner for current activities (such as our own projects Hands-On Technology [1993-1999] and Step In—Mentoring & Mobility [2001-2003], which will be described later). Computer science was and is generally an integral component in the projects. However, there is a difference between computer science as an independent subject and its application in a technical discipline. Concepts have been developed for both aspects. Activities for the promotion of women in Germany are currently somewhat one-sided with the emphasis on computer science.

Little Increase in Female Proportions in Technology and Science

In spite of these promotional efforts, the proportion of females in those "hard" courses in natural and computational sciences and in fields of technical studies and occupations remains small, though 45% of all students are female and 50% of the students in university beginning studies are female. Over the last decade the activities to encourage women have only slightly increased their percentages in the above-mentioned fields. The rate of female students increased in electrical engineering from 4.4% in 1992 to 8.6% in 2001, in mechanical engineering from 5.3% in 1992 to 10% in 2001, and in computer science from 13% in 1992 to 19% in 2001 (Federal Ministry of Education and Research, 1993–2002). The increase in women, even if small, may be explained by the efforts in the context of promotion activities for women, that is, the projects have been nevertheless successful.

Consequences

The above-mentioned increases in women's participation need to continue at a greater pace. This could happen if the projects could take long-term perspectives into account and not merely exist at brief intervals. Those who engage in promotional efforts, and all educators, for that matter, need to be aware of several other factors that may affect women's interest and participation in the technology fields.

Self-Concept (Self-Efficacy Belief), Gender, and Technology

Self-concept gained scientific attention for explaining the exclusion of women from technological fields, particularly young women's lack of confidence in their own efficacy to handle technical situations adequately.

The concept of self-efficacy (Bandura, 1997) has gained popularity in recent years, especially in educational and vocational issues. When choosing a career, perceived self-efficacy has long-term consequences. People with high self-efficacy expectations consider a wider spectrum of possibilities to develop themselves in relation to specific subjects and vocations and hold higher aspirations. For example, when choosing a career in mathematical/technical fields, high perceived self-efficacy bears more relevance than actual quantitative and technical competence (measured according to education and capabilities; Hackett & Betz, 1989). Subjective self-efficacy judgments are one of the most relevant determiners of success and persistence in a career.

Perceived self-efficacy refers to the beliefs in one's personal capabilities to organize and execute the courses of action required to manage prospective situations (Bandura, 1997). Self-efficacy produces effects in various ways, including mainly cognitive, motivational, affective, and selection processes.

People who have a low sense of efficacy in a given domain

- shy away from difficult tasks,
- have low aspirations and a weak commitment to goals,
- slacken their efforts and give up quickly in the face of difficulties, and
- diagnose insufficient performance as deficient aptitude and lose faith in their capabilities.

Self-efficacy beliefs are products of complex processes of self-persuasion. These processes rely on the cognitive "working up" of diverse efficacy information.

Bandura (1997) designated four sources of self-efficacy that can help to dispel doubts concerning one's own self-efficacy perceptions. These sources may enable persons to deal effectively with certain situations, each including

- mastery experiences, an enactive factor;
- vicarious experiences, influenced by perceived similarities to role models, observed;
- coping processes and participant and corrective modeling;
- encouragement from one's environment (e.g., social and/or verbal persuasion); and
- positive interpretations of one's physiological and emotional states.

Women generally judge themselves as being less efficacious then men for scientific occupations requiring quantitative skills, such as engineering and computing (typical male vocations where the percentage of women is equal or less than 25%), whereas men judge themselves less efficacious than women for education and psychology (typical female occupations where the percentage of men is equal or less than 25%; Wender, 1999).

Hackett (1995) provided empirical data that supports the theory that the low proportion of women in technical vocations can be traced back to women's low perceived self-efficacy regarding technical problem-solving skills.

Because gender groups experience socialization differently, girls and young women find it difficult to attain technical information and experience, and when they do, they cannot adequately process it. Women are hindered in building up and enlarging high self-efficacy expectancy for the technical and engineering fields. This is connected to a high degree of gender and social role model stereotyping.

A stereotype is a set of qualities ascribed to all members of a group of people or objects because of overgeneralization. Alfermann (1996) pointed out that women are perceived as preferring social relationships. For example, a woman is regarded and regards herself as preferring social relationships. Social roles are distinguished through behavioral expectations that society assigns as norms to members of a certain group. According to Alfermann, even today it is still usual that women take care of children and stay at home after the birth of a child and men do industrial work.

In accordance with the stereotype that describes women as incompetent in natural science and technology, girls often underestimate their own performance in mathematics and natural sciences. The TIMMS studies confirmed gender differences regarding confidence in one's own capabilities in these subjects and concluded that even very capable, highly successful female students tend to underestimate their own capabilities and assign success more to luck or accident (Baumert, Bos, & Lehmann, 1997).

Gender stereotypes and gender role expectations also influence expectations of different agents of socialization. Parents, teachers at schools and universities, and instructors in business develop expectations of their children, their students, and their trainees. Thus, a sort of self-fulfilling prophecy sets in and all involved base their behavior and experience on expectations set up by social groups. Even persons being educated follow these expectations, be they positive or—as concerning girls in relation to technology—negative for themselves.

The Function of Interests

According to Hannover (1998, in press), self-concepts are closely related to interests, and these, in turn, are closely related to vocational decisions. Self-concept influences the development of interests, and interests shape self-concept. Both determine the decision to pursue a subject or a vocation.

Todt and Schreiber (1998) defined interest as follows:

> Interests are domain-specific behavior—and experience activating and controlling motives, which are generalized, serving as structures of orientation and appearing in a specific manner as preferences for activities. Interests are essential elements of the structure of self-concept and are fully integrated in the individual's self-concept. (p. 25)

They also differentiated three forms of interest:

- General interests: content and age related, relatively enduring, whereby the influence by concrete experience is rather small, their function exists in orientation.
- Specific interests: relatively enduring, dependent on external hint and on positive experience, related to relatively specific contents or activities and to specific competence, their function exists in initiation activities.
- Active interests: positive emotional state, dependent on specific characteristics of situations, for example, success, positive social-emotional climate, can become dispositional if, for example, stabilized by positive consequences, their function exists in activating cognitive functions and stability activities.

As studies have shown, girls and boys, women and men have differing interests. Women prefer animated content, having something to do with people, having an obvious relationship to everyday life, relating to natural phenomena and of some use to humanity. Men, on the other hand, are less context dependent; they are more readily fascinated by apparatus and machines as such and concentrate on the object at hand (e.g., Häußler & Hoffmann, 1998). These elements can be distinguished as general interests; they are aligned with orientation and hardly available to change by experience. Since they are considered relatively stable, they must be taken into account in developing activities to promote an increased interest of women in technology and natural science.

In contrast, differing interests relating to individual subject areas such as German and physics can be affected by experience because they are specific interests. They can be influenced and affected by active interests. According to Todt and Schreiber's (1998) model, positive feedback, success, and a positive social-emotional climate closely associated with the various subject areas can influence them.

Hannover (1998) established that real life behavior experiences in the particular subject area are especially influential factors. Practical experience gives knowledge about content that is integrated into knowledge structures and anchors the corresponding interests as a personal experience and part of self-applied knowledge. These interests initiate new activities that contribute to the expansion of object-knowledge, of self-knowledge, and of the creation of self-concept. Thus, these components evolve into a circular process.

Hannover (1998) and Hannover and Kessels (2002) support the theory that in coeducational school situations, particularly with exercises that revolve around technology, gender segments of self-concept are activated and control interests in adolescents because of the presence of people of the opposite sex. In school situations where only women are present in a learning group, the gender-related segment becomes relatively inactive, and interests could develop independently. So if girls' interests should be turned to technology (against the gender stereotype), gender separate teaching is advisable.

These statements are empirically supported by the fact in 1980 young women studying technology or the natural sciences in Germany mainly graduated from girls' schools (Jahnke-Klein, 2001). And as Metz-Göckel (1999) stated, graduates from the women's colleges are very successful both in science and in the labor market.

Encouraging Women Into Technology and Science

Summarizing the preceding paragraphs, one may conclude that young women aged 15 to 20 are encouraged into technology and natural sciences if the following preconditions are taken into account.

- Regarding self-efficacy (Bandura, 1997):
  - Active, physical approach to technical problems.
  - Support from female role models.
  - An atmosphere that encourages confidence.
  - Help to interpret possible tension as positive stress.
- Regarding general aspects of interest (Häußler & Hoffmann, 1998):
  - Inclusion of technical problems in everyday situations or an everyday context.
  - Consideration of relationship with life, particularly with people.
  - References to natural phenomena.
  - Possibility to recognize human or social usefulness of the exercise.
- Regarding the aspect of specific and active interest (Todt & Schreiber, 1998):
  - Active examination of technology.
  - Acquisition of technical knowledge.
  - Creation of a positive social climate.

It should be stressed, though, that knowledge, self-concept (and in particular belief in self-efficacy), interests, and choices/decisions of vocation are closely related and mutually dependent.

In order for girls to avoid activating gender-related knowledge, a gender separate learning situation should be available (Hannover & Kessels, 2002). This would contribute to building up their perceived self-efficacy and promote development of a young woman's quantitative and technical talents. Future women engineers need to be provided with a learning environment that promotes and supports feminine general interests, giving them the opportunity to develop specific interests for natural science and technology to maximize their potential in these fields. Such schooling would induce girls and young women to gain technical knowledge, make them aware of their own competencies, give them a chance to develop specific interests beyond gender stereotypes, and give them the opportunity to acquire vocational skills in technology and natural science.

Projects of the Universities in Brunswick to Encourage Women

The projects of the universities in Brunswick, Hands-On Technology (1993-1999; Wender, Strohmeyer, & Quentmeier, 1997) and Step In—Mentoring & Mobility (2001-2003; Wender, Popoff, Peters, Müller, & Foetzki, 2002), are based on the social-cognitive modification strategies of Bandura (1997) as well as on the previously cited views of Hannover (in press), Häußler and Hoffmann (1998), and Todt and Schreiber (1998) in relation to interests. They combine activity-related measures (e.g., technology days or camps, computer workshops) with a mentoring program for schoolgirls, students, and experts from technology. The Step In—Mentoring & Mobility project concentrated its content on an interdisciplinary subject, that is, mobility/traffic with its technical, social, ecological, and psychological aspects.

The focus of the projects were on

- increasing knowledge of vocations in science and technology,
- increasing perceived self-efficacy of quantitative and technical tasks,
- increasing interest in technical fields, and
- considering occupational possibilities that include technical tasks as the dependent variables.

Several intervention modules were designed and applied. Established practices used in classes training students for their choice of future occupations were changed or complemented for the purposes of these projects: a three week-period of practical work, courses and vacation camps over several days designed for young women to develop interest in natural and technical sciences and computational science. In order to develop career orientation, a course lasting one week was offered to young women and men. The course included a work company over two days in business for the young women in technical domains and for the young men in social and educational domains.

In order to guarantee long-term promotion for the young women in the project Step In—Mentoring & Mobility, a particular mentoring program was conducted after the end of the vacation camp that offered special coaching for several months. During the camp the girls had the opportunity to write down their wishes for the mentoring program in a questionnaire.

Below follows an example of the practical studies offered yearly between 1993 and 1998 by the Hands-On Technology project . These three-week courses were attended by 120 young women (aged 15 to 20) in the above-mentioned period. The text is taken from an information brochure that advertised these practical studies in schools.

> ***Institute of Flight Guidance and Control Technical University of Brunswick/ Germany***
> During their practical courses, trainees are involved in the preparation, the carrying out and the evaluation of simulation-and flight-experiments in a flight simulator. Different methods of approach and landing procedures, different turns and wind situations or specific motor flights are being tested and analyzed. These experiments aim at the test of new flight techniques in order to increase security standards in air traffic.
>
> Moreover, trainees will get to know the evaluation of measured atmospheric data, such as pressure, density and temperature or data from real flight experiments such as position, velocity vector or air data. This includes an introduction to the measuring instruments of our plane at the research airport Braunschweig. Main aim of this survey at our institute are both the development and the test of new measuring techniques.
> Instructor: Dipl. Ing. Ronald Blume

The main activity of the Step In—Mentoring & Mobility project is a mobility camp in the summer holidays that was executed in 2001 for the first time and will be repeated in 2003. More than 50 girls participated in the first camp. For one week, girls have the possibility to take an active role in technology by working on two projects each. During the mornings, projects are offered at different technological institutes. These projects mainly deal with actual research in the field of mobility. During the afternoons, the projects concentrate on practical, social, ecological, and psychological aspects of the topic.

Below follows an example of the practical project work offered by Step In—Mentoring & Mobility in the framework of the above-mentioned mobility camp. The text is taken from an information brochure that advertised the camp in schools.

> Who likes shaking cars?
> How to transfer driving test collected data on vehicle vibration to a hydraulic simulator for a survey on driving comfort
>
> ***Institute of Vehicle Engineering, Technical University of Brunswick/Germany***
> The topic of driving comfort plays an important role in the development of cars as it is one of the main qualities in people's judgement of motor cars. Therefore, knowledge of human vibration-perception—how do people perceive and judge different vibrations—is of great importance for automotive industry.
>
> By shifting the analysis of this vibration-perception from the road to a simulator, one not only reduces the amount of expensive driving tests, but also offers additional flexibility to the survey methods.
>
> In this project, you are introduced to the

main tools and processes involved in the transfer of real vehicle movements to a test bench. You may independently equip a car with measuring technique and make measuring drives on the institute's grounds in order to collect data on the vehicle's vibrations. In the end, you transmit these to the institute's simulator.
Instructor: Dipl.-Ing. Thorsten Bitter

The above-mentioned activity-related measures not only offer the possibility to actively approach and experience technology, but, moreover, give the opportunity to form or renew mentoring relationships. Specific mentoring workshops also facilitate an interchange between schoolgirls, students, and experts from technology. These workshops train female experts for their role as mentors and role models, especially by showing their behavior in male-dominated contexts. They also give the opportunity to acquaint key qualifications.

The Step In—Mentoring & Mobility mentoring program was developed especially to consider the needs of schoolgirls. Temporally restricted forms of group mentoring as part of activity-related project measures are of great importance for the mentoring process. Individual contacts between a schoolgirl and several mentors often continue after the group measures are completed.

Evaluation

In order to guarantee a constant improvement of the intervention program, all parts of the projects are being regularly evaluated. Among other things, participating girls have to fill in pre- and post-participation questionnaires, concentrating on knowledge, self-efficacy belief, interests related to technical fields, and the choice of vocation, as well as the expectations and experiences from the different aspects of the project. Moreover, our own observations, audio and video recordings, and posters and reports made by the girls are part of the analysis. Participating tutors and mentors are also questioned in order to modify and constantly improve the programs.

Two examples of the evaluation are described here. The first example relates to the Hands-On Technology project, concentrating on the three-week period of practical work courses that were offered yearly between 1993 and 1998 and were attended by 120 young women (aged 15 to 20). The second example relates to the Step In—Mentoring & Mobility project and to its main offer, a summer camp, organized for the first time during the summer holidays in 2001. Fifty young women (aged 15 to 20) participated in this camp.

In the Hands-On Technology project the previously mentioned dependent variables were measured for the three focus fields (civil engineering, mechanical engineering, and electrical engineering) in pre- and post-participation questionnaires. The data were collected based on Betz and Hackett's (1981) measurement instrument. The statistical analysis compared the data collection for knowledge, self-efficacy, interests, and possible choice of vocation before and after the intervention of the intervention group (only women) with the control groups (women or men in three week-period of nontechnical practical studies). Follow-up analysis of the data was completed with the help of the Kruskal-Wallis one-way ANOVA (see Wender et al., 1997).

Between the intervention and control groups high significant differences were found with respect to the perceived self-efficacy related to the field of engineering; significant differences appeared with respect to knowledge and to interests; a numerical tendency was found with respect to possible choice of vocation. Most changes in the pre- and post-questionnaires were found in the intervention group.

As one result of Step In—Mentoring & Mobility, data were collected from young women participating in the summer camp. The questionnaires were based on the dependent variables previously mentioned, concentrating on vocations in the domain of traffic. Again, data were collected before and after the intervention.

The statistical analysis was done with the help of the Wilcoxon test. The data showed a significant increase after the intervention on all measured variables (see Wender et al., 2002).

Conclusion About Intervention

It is safe to conclude that the intervention programs were and still are successful. The questionnaires show significant changes regarding the schoolgirls' knowledge, their self-efficacy beliefs, and their interests in technology. Their newly gained and/or more consciously experienced knowledge and interests led to new perspectives concerning the girls' choices of vocations. They now consider more vocations, generally differing from stereotypically female ones. Their possible choices of vocation therefore significantly rose due to their participation in the project.

The mentoring workshops led to significant changes regarding the self-confidence of both schoolgirls and mentors in male-dominated conflict situations. Moreover, network-building can be noticed among all participating groups.

Therefore, when women are given the opportunity to engage in technical tasks and to succeed—and by doing so not to correspond to traditional gender stereotypes—they are contributing to the decline of the male stereotype traditionally connected with the perception of technology.

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References

Alfermann, D. (1996). *Geschlechterrollen und geschlechtstypisches Verhalten* [Gender roles and sex typing behavior]. Stuttgart, Germany: Kohlhammer.

Bandura, A. (1997). *Self-efficacy—The exercise of control.* New York: Freeman.

Baumert, J., Bos, W., & Lehmann, R. (1997). *TIMM: Mathematisch-naturwissenschaftlicher unterricht im internationalen Vergleich* [TIMMS: International comparison of mathematics and science teaching]. Opladen, Germany: Leske + Budrich.

Betz, N. E., & Hackett, G. (1981).The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of Counseling Psychology, 28,* 399-410.

Federal Ministry of Education and Research. (1993–2002). *Grund- und strukturdaten* [Basic and structural data]. Magdeburg, Germany: Garloff Druckerei.

Hackett, G. (1995). Self-efficacy in career choice and development. In A. Bandura (Ed.), *Self-efficacy in changing societies* (pp. 232-258). New York: Cambridge.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal of Research in Mathematics Education, 20,* 261-273.

Hannover, B. (1998). The development of self-concept and interests. In L. Hoffmann, A. Krapp, K. Remminger, & J. Baumert (Eds.), *Interest and learning* (pp. 105-125). Kiel, Germany: IPN.

Hannover, B. (in press). Vom biologischen zum psychologischen geschlecht: Die entwicklung von geschlechtsunterschieden [From sex to gender: The development of sex differences]. In A. Renkl (Ed.), *Pädagogische psychologie* [Educational psychology]. Bern, Swiss: Huber.

Hannover, B., & Kessels, U. (2002). Monoedukativer anfangsunterricht in physik: Auswirkungen auf motivation, selbstkonzept und kurswahlverhalten von gesamtschülerinnen und gesamtschülern [Monoeducational elementary courses in physics: Effects on motivation, self-concept, and course selection pattern of pupils in comprehensive schools]. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie, 34,* 201-215.

Häußler, P., & Hoffmann, L. (1998). Qualitative differences in student's interest in physics and the dependence on gender and age. In L. Hoffmann, A. Krapp, K. Remminger, & J. Baumert (Eds.), *Interest and learning* (pp. 280-289). Kiel, Germany: IPN.

Jahnke-Klein, S. (2001). *Sinnstiftender mathematikunterricht für mädchen undjJungen* [Meaningful mathematics teaching for girls and boys]. Hohengehren, Germany: Schneider Verlag.

Metz-Göckel, S. (1999). Was Frauen an ‚Women's Colleges' lernen können [What women can learn in women's colleges]. In M. A. Kreienbaum (Ed.), *Schule lebendig gestalten* [Forming schools full of life, pp. 62-71). Bielefeld, Germany: Kleine Verlag.

Ostendorf, Helga (1994). Öffnung von männerberufen für frauen [Opening the men's jobs to women]. *WSZ Mitteilungen, 47,* 752-762.

Todt, E., & Schreiber, S. (1998). Development of interests. In L. Hoffmann, A. Krapp, K. Remminger, & J. Baumert (Eds.), *Interest and learning* (pp. 25-40). Kiel, Germany: IPN.

Wender, I. (1999). *Einblicke in die entwicklungspsychologie,* Teil III [Insight into developmental psychology, Part III]. Aachen, Germany: Shaker.

Wender, I., Strohmeyer, A., & Quentmeier, B. (1997). *Technik bewegt die frauen—frauen bewegen die technik* [Technology moves women—Women move technology]. Aachen, Germany: Shaker.

Wender, I., Popoff, A., Peters, A., Müller, K., & Foetzki, C. (2002). *Step in—Mentoring & mobilität. Zwischenbericht* [Step in—Mentoring and mobility. An interim report]. Braunschweig, Germany: Sigert.

Malaysia Transitions Toward a Knowledge-Based Economy

By Ramlee Mustapha and Abu Abdullah

The emergence of a knowledge-based economy (k-economy) has spawned a "new" notion of workplace literacy, changing the relationship between employers and employees. The traditional covenant where employees expect a stable or lifelong employment will no longer apply. The retention of employees will most probably be based on their skills and knowledge that can create advantages for the company over its competitors. Employers invest in the skills of their employees to improve productivity and the profitability of the company. Training costs can be substantially higher than that of general or academic education but are justified when the value of the company's earnings and productivity exceed the cost of the training. Numerous empirical studies regarding entry-level employee competencies from the perspective of employers have been conducted in both industrialized and developing nations. The results of the studies found that employers prefer certain types of entry-level competencies of the prospective employees. This article provides an overview of workplace literacy from the perspective of the employers and also reviews pertinent literature regarding Malaysia's transition toward a k-economy.

K-Economy

In the information age, knowledge is power. The k-economy is based on a paradigm that focuses on intellectual capital as a prime mover. With knowledge replacing physical and natural resources as the key ingredient in economic development, education and human resource development (HRD) policies require rethinking. While there is no standard definition of a k-economy, the UK Department of Trade and Industry defined it as a knowledge-driven economy in which the generation and exploitation of knowledge play the predominant role in the creation of wealth (Economic Research Services Department, 2000). Meanwhile, the Organization for Economic Cooperation and Development (OECD, 1996) defined a k-economy as an economy that is directly based on the production, distribution, and use of knowledge and information.

Investment in human capital is critical in a k-economy. Human capital theory views education and training as an investment that can yield social and private returns through increased knowledge and skills for economic development and social progress (Schultz, 1963). The economic argument in favor of knowledge-based education and training is linked to the perceived need of the global economy. It is based on the assumption that economic growth and development are knowledge driven and human capital dependent.

Despite a growing emphasis on knowledge-based education and training, minimal research exists with respect to the new workplace literacy especially from the employers' perspective. Therefore, this article attempts to provide an overview of workplace literacy from the perspective of the employers and also reviews pertinent literature regarding Malaysia's transition toward a k-economy.

Workplace Literacy: Employers' Perspective

Murphy and Jenks (1983) conducted interviews to identify the traits of successful entry-level professional employment applicants. The job opportunities investigated were either management trainee, junior-level professional, or apprenticeship positions. Employers clearly indicated that both functional and adaptive skills were needed. There was also a clear preference for certain types of skills. Nearly 40% of the responses related to communication and persuasion skills. Adaptive skills identified by the employers included a wide range of attitudes, personality traits, and work habits. Competition is a major factor that motivates industry to be more efficient and to employ strategies that will improve production, service, and product quality. Because such strategies usually require workers' collaboration and teamwork, employers need creative, flexible workers who have a broad range of interpersonal and managerial skills.

Junge, Daniels, and Karmos (1984) surveyed 116 large U.S. companies to rate the knowledge and skills of employees related to mathematics, writing, reading, speaking, listening, reasoning, and science. The purpose of the survey was to determine the perceptions of employers regarding the workplace literacy that is important for successful employment. They found that speaking, listening, and writing followed by reasoning and reading skills were regarded as important requirements for successful employment. The most frequently cited qualities were good attitude toward work; willingness to adapt and learn; getting along with others; neat and appropriate appearance; promptness; infrequent absence from work; familiarity with basic computer knowledge; and good oral, written, and listening skills.

Research has also revealed reasons for rejection of job applicants and termination of employees. In a survey of employers conducted by the Advisory Council for Technical and Vocational Education in Texas, the reasons provided by employers for rejecting job applicants included little interest for wanting the job, past history of job hopping, poor communication skills, health problems, immaturity, personal appearance, poor mannerisms, personality, lack of job-related skills, and poorly completed application forms (Brown, 1976).

Zakaria (1988) studied the perceptions of Malaysian employers regarding essential employee traits and employability skills. Employers rated arrive on time, demonstrate a sense of responsibility, cooperate with the supervisor, and possess a positive attitude toward work as the major desirable employee traits.

In 1989, Lieberman Research Incorporated conducted a study of 1,000 senior executives of FORTUNE 500 companies to explore the beliefs of the executives regarding the American public education system (Lieberman Research

Inc., 1989; Passmore, 1994). Most of the responding employers were highly critical of the public education system. Approximately two thirds of the respondents asserted that their companies had difficulties hiring employees because of basic skill deficiencies of job applicants and that identifying potential employees with adequate basic skills was becoming more difficult. Clearly, employers preferred employees who were motivated, possessed basic skills, and had satisfied a higher performance standard.

The Employment and Training Administration of the U.S. Department of Labor and the American Society for Training and Development (ASTD) conducted a survey of employers seeking potential employees (Passmore, 1994). They found that many employers valued basic literacy—reading, writing, and computing. In addition, the employers preferred employees who had motivation to learn; could communicate, especially through listening and oral communication; could adapt through creative thinking and problem-solving skills; possessed effective personal management skills; had interpersonal, negotiating, and teamwork skills that made them effective workgroup members; and could influence others to act through leadership skills. Moreover, employers preferred to conduct their own technical skills training but only with employees who possessed basic skills (Carnevale, Gainer, & Meltzer, 1990).

The Harris Education Research Center (HERC, 1991) assessed the views of employers, educators, parents, and students regarding American education. Employers clearly indicated that their new employees were borderline in terms of functional literacy, capacity to express themselves, and basic functional skills. In contrast, students and parents thought that their schools were doing well (Passmore, 1994).

The U.S. Department of Labor Secretary's Commission on Achieving Necessary Skills (SCANS, 1991) examined the literacy required to enter employment using interviews with business owners, public employers, union officials, and line workers. The SCANS report identified five major competencies and three foundation areas that were required for entry-level job performance. Basic skills, thinking skills, and personal qualities formed the foundation on which the five broad competencies were constructed. Basic skills included reading, writing, arithmetic, mathematics, speaking, and listening. Thinking skills included creative thinking, decision making, problem solving, abstract visualizing of problems, knowing how to learn, and reasoning. Desirable personal qualities included individual responsibility, self-esteem, sociability, self-management, and integrity.

Distler (1993) studied attitudes and perceptions of Maryland's employers toward vocational education and employment training programs. The majority of the employers indicated that the present educational approach is not sufficient to train students effectively for the changing demands of the workplace. If vocational and training programs are to be effective, cooperation among educators, legislators, employers, and the community must be established.

An investigation by Custer and Claiborne (1995) supported previous research in which employers placed more emphasis on employability skills rather than on technical skills. They surveyed 299 U.S. employers in the health, trade, and industry occupational areas. The purpose was to explore employers' priorities regarding the types of skills they perceived to be critical to their needs and the workforce. The findings revealed that the most important skills cluster was employability skills. Basic skills ranked second and technical skills third.

A recent empirical research on the perceptions of Malaysian employers regarding employability and workplace literacy was conducted by Mustapha (1999). The purpose of the study was to examine employers' perceptions regarding the critical workplace literacy and employability skills of vocational graduates. The sample consisted of 120 employers from large and medium-sized manufacturing companies. The study found that employers believed that the completers of vocational and technical programs had better employment opportunities than completers of academic programs. Further, employers indicated that vocational and technical graduates possessed necessary technical skills. However, employers were less satisfied regarding the graduates' motivation, communication, interpersonal, critical thinking, problem solving, and entrepreneurial skills. This clearly suggests that affective and employability skills should be integrated into vocational and technical programs. Technical competencies were perceived by Malaysian employers as the most important knowledge and skills that vocational and technical graduates should possess. They also believed that communication and interpersonal skills are important. These results seem to support previous research regarding the importance of employability skills (Custer & Claiborne, 1995; Greenan, Wu, Mustapha, & Ncube, 1998; HERC, 1991; Lieberman Research Inc., 1989).

Malaysia Transitions Toward Knowledge-Based Economy

The shift to the k-economy is part of a wider plan to achieve the objective of the nation's Vision 2020. Vision 2020 is a 30-year plan to "push" Malaysia to achieve a level at par with industrial nations in terms of economic performance and technological capability (Mustapha & Abdullah, 2000). With the move toward a k-economy, the country can achieve sustainable Gross Domestic Product (GDP) growth rates in the long run with knowledge playing a dominant role in driving productivity and sustaining economic growth. It is projected that through an information and knowledge-based economy, the level of the country's GDP can increase four fold within 20 to 25 years (Economic Research Services Department, 2000).

However, Malaysia currently lacks some of the critical elements to support the k-economy. Among them are the lack of adequate knowledge and skilled human resources, inadequacy of a k-economy supportive education and training infrastructure, a lack of R&D capability, a relatively weak science and technology base, a deficiency in institutional support and infostructure, a slowly evolving financing system, and a lack of technopreneurs (Govindan, 2000).

The new global market calls for visionary leadership and the adoption and application of new management and organizational principles. The old command-and-control management system that many Malaysian organizations are used to may not work in a new competitive environment. The education, training, and employment policies have to change. Employers need to recruit "knowledge" workers for higher skills jobs. This requires our education system to produce graduates with relevant knowledge, critical and higher order skills, and proper attitudes.

IT Infrastructure

Tangible evidence of Malaysia's commitment to the k-economy is the Multimedia Super Corridor (MSC). This 50 x 15 km wide corridor stretches from the center of Kuala Lumpur to Cyberjaya, a newly established city approximately 40 km south of Kuala Lumpur, and is designed to incubate high technology companies. When the MSC was first announced in 1995, it was estimated that the government would spend RM 28 billion (approximately USD 7.4 billion) to develop the infrastructure and facilities required to attract international high technology companies (Mohamed, Hasan, Dzakiria, & Kassim, 1999).

It aims at revolutionizing IT and multimedia industries by creating a massive corridor with a conducive environment for local and international companies wanting to create, distribute, and employ IT and multimedia products and services (Abdul Manab & Othman, 1999). MSC is also expected to place Malaysia as a regional and international technology and telecommunication hub. The MSC will propel the transfer of technology and become the test bed for R&D in high-tech industries (Mohamed et al., 1999).

Due to the increasing demand for knowledge workers to work in the IT and high-tech industries of the MSC, the Smart School program was adopted as one of the seven flagship applications. The flagship will support the government's plan to obtain the status of an industrialized nation by the year 2020 and to gain a competitive edge over other developing countries in the global economy (Mohamed et al., 1999). In the Smart School concept, learning will be self-directed, individually paced, contextualized, and reflective using IT as a prime enabler (Abdul Manab & Othman, 1999).

It is hoped that, eventually, all schools in this country will be smart schools.

Despite the MSC project, schools in Malaysia continue to lag behind other sectors such as business and entertainment in utilizing IT and multimedia technologies. A majority of schools still do not have enough computers and Internet facilities for most students to use frequently. However, during the last decade the increase in IT access and the emergence of new telecommunication technologies have somewhat changed how teachers perceive technology and its applications in teaching and learning.

The IT literacy among Malaysian students has not yet reached its satisfactory level. To reach its maximum potential requires full commitment, serious thinking, research, and experimentation. Although Malaysia has made great strides in enhancing its IT infrastructure, IT utilization and structure in educational institutions are still inadequate. Teachers and administrators should reevaluate and restructure the curriculum so that the curriculum is viable for IT literacy to be developed among students (Mohamed et al., 1999). Therefore, the administrators and educators should be urged to plan the curriculum carefully and systematically in meeting the needs of the society as a whole.

Policy Implications on New Workplace Literacy

Highest Level Commitment

The Malaysian government has already recognized the importance of adapting to this new economy and is committed to transform the economy from a production-based to a knowledge-driven economy. The prime minister during his official speech at the launching of the information technology campaign in 1997 stated that IT is at the forefront of the country's national socioeconomic planning and development. The government formulated the National Information Technology Agenda (NITA) in 1996 to provide the country with the direction and the way forward with IT. The NITA has spelled out a three-pronged strategy aimed at developing a knowledge society through building and developing the appropriate IT structure, the creation and development of IT-based applications, and human development effort. In order to achieve this, the balanced development of three important, interrelated elements that involve people, infostructure, and applications are stressed (Economic Research Services Department, 2000).

K-Economy Master Plan

The Malaysian K-Economy Master Plan outlines the major k-economy policy initiatives. Planned reforms in the education sector include further privatization, twinning arrangements with foreign institutions, and the construction of advanced technical institutes and community colleges. Infrastructure will be developed that allows for the use of electronic diagnostic tools in hospitals and networking among government departments, their suppliers, and their customers. Increased bandwidth is planned to facilitate greater e-commerce capacity. A draft of amendments to various financial regulations aims to create a more favorable investment climate for local and foreign firms, particularly those in designated high technology sectors. It also includes profit repatriation and taxation arrangements designed to lure foreign investors back. This is in addition to a very publicized crackdown on software piracy. Overall, the initiatives aim to address the serious shortages of knowledge and skilled workers in Malaysia and to attract much-needed foreign investment and expertise, particularly in alliances with local firms and institutions.

IT Literate Society

Reflected in a particular k-economy initiative, the "One Home-One PC" policy allows workers to withdraw their contributions to the Employees Provident Fund (a retirement fund) to purchase a personal computer. This initiative supports a long-term plan to link 25% of the population to the Internet by 2005. Another initiative is the "Internet Desa" (Internet for rural areas) program, which aims to provide Internet access and basic computer skills to people in rural areas via a networked personal computer located in their local post office.

National Information Technology Council

The National Information Technology Council (NITC) was established in 1994 to guide the country toward the knowledge empowerment of Vision 2020. The NITC aims to enhance the development and utilization of IT as a strategic technology for national development. The NITC acts as a think-tank at the highest level and advises the government on matters pertaining to the development of IT in Malaysia (Infosoc Malaysia, 2000). The government's commitment toward the creation of a k-economy is also evidenced by the development of the Multimedia Super Corridor, the idea mooted in 1994, and the creation of a pioneer legal and regulatory framework encompassing, inter alia, the Communication and Multimedia Act, the Computer Crimes Act, and the Digital Signatures Act (Economic Research Services Department, 2000).

Development of Knowledge Workers

The creation of quality human resources is important in a k-economy. These individuals will form the backbone of the k-economy. Knowledge workers are versatile, autonomous, and highly skilled and are able to leverage and build knowledge to produce useful action with very strong and analytical skills. They are flexible and have a high tolerance for ambiguity. For Malaysia to produce a pool of k-leaders and k-workers, the educational system needs to be revamped and restructured. The focus should be directed to making the existing curriculum more innovative to help students to invent and develop a critical and analytical mode of thinking and ultimately create a sufficient pool of well-educated, highly skilled and strongly motivated workers (Economic Research Services Department, 2000).

The use of IT in teaching and learning should facilitate knowledge construction and engage learners in constructive, higher order, creative, and critical thinking (Jonassen, 1996). It should also develop team-based collaboration and communication skills for solving real-life problems. Teachers must redesign their instructional material to include the use of IT as a cognitive tool rather than a mere delivery medium.

In this area, the government has already taken the initiative of introducing the Smart School project, which was launched during the review of the Seventh Malaysia Plan (1996-2000). The objective of the project is to produce a new generation of IT-literate Malaysians who are creative and innovative, adept with new technologies, and able to access and manage information to enhance the competitiveness and productivity of the economy. At the same time, the government is campaigning hard to woo back Malaysians who are now working overseas. In March 2000, the prime minister announced a campaign to attract 5,000 skilled foreign workers a year to help the nation into the information age to ensure a massive brain gain, an infusion of men and women of extraordinary talent, creativity, knowledge, skill, and other capabilities (Economic Research Services Department, 2000).

To advance Malaysia into the forefront of knowledge, investment in human capital is critical, as a k-economy demands creative, innovative, and knowledgable human resources. It is for this reason that the state has continued to allocate a substantial portion of the national budget for financing the expansion and upgrading of education and training facilities. However, human resource development needs to be further intensified, particularly through public-private sector collaboration in building science and technology human resources as well as the intellectual capability and competency in management and entrepreneurship. In this regard, opportunities for lifelong learning for all levels of the workforce should be enhanced through this collaboration.

Rigorous Research and Development

The structure of the economy becomes less distinct in the k-economy. Nevertheless, the manufacturing sector, which accounts for more than one third of the GDP of the country, still continues to assume an important role in the k-economy. However, in view of the migration of the economy from production based to knowledge based, the manufacturing sector would have to gear up to adjust to the rapid change in technological advancement by improving its products through R&D and enhancing the pool of "knowledge" workers (Economic Research Services Department, 2000).

In a k-economy, it is crucial to develop the R&D and the services sectors. It is generally known that the level of development of the services sector, particularly the knowledge

Table 1. Knowledge-Workforce Among Selected Countries

Selected R&D Statistics (1997)			
Countries	K-Skills Workforce (as % of total workforce)	R&D/ GDP (%)	K-Skills in R&D (per million population)
Malaysia	10.7	0.3	87
Singapore	26.4	1.4	2,512
Korea	15.1	2.8	2,636
Taiwan	15.5	1.9	3,340
Japan	22.9	2.8	5,677

Note. Data source: Bank Negara Malaysia, 2000.

intensive segments of it, has become a key determinant of the national competitiveness. There are many compelling reasons for Malaysia to develop its services sector. To begin with, expanding this sector helps create national wealth: A positive correlation exists between high GDP per capita and the intensity of services activity in the economy, mostly because compensation levels in this sector normally surpass those in agriculture and manufacturing (Economic Research Services Department, 2000). Moreover, in economies with a strong emphasis on services, people tend to climb the "value-chain ladder" much more rapidly. It is generally believed that in the k-economy, the information-related industries and knowledge-intensive industries play the dominant role.

Innovation is one of the key success factors in a k-economy, and it is R&D that determines innovation. According to the OECD (1996), the proxies generally used to represent the production of new ideas and innovation is R&D expenditure and the number of patents. Based on some available relevant statistics (see Table 1), it is apparent that Malaysia currently has a relatively low k-workforce and R&D investment.

Creativity, Innovation, and Entrepreneurship

IT leaders and business gurus believe that the new economy is about the power of ideas and knowledge, which is why it is important to encourage entrepreneurship in Malaysia. Entrepreneurship is a collaborative effort. It may be easy to generate ideas, but hard to provide a conducive environment to allow the ideas to kick-start and grow. School systems at all levels should include entrepreneurship in their curriculum. It should focus on creating new and innovative ideas by the students and converting them into full-fledged business plans for future use.

Infrastructure, Accessibility, and Connectivity

There must be affordable and equitable access and connectivity to ensure that all levels of society can participate in the new economy. Businesses and citizens must have access to a low-cost, high-speed communication infrastructure. This is key to balanced urban and regional development across the country. Reducing access costs plays a major role in this context. In terms of accessibility to the IT infrastructure, Malaysia performed better compared to other developing countries, but the situation reversed when compared with advanced countries. Table 2 shows the number of personal computers and Internet hosts in Malaysia vis-à-vis other countries.

Table 2. Indicators of Communication and Information Infrastructure Among Selected Countries

Indicators of Communication and Information Infrastructure in 1996		
Countries	No. of Personal Computers (per 1,000 population)	No. of Internet Hosts (per 1,000 population)
Malaysia	43	19
United States	362	442
United Kingdom	193	149
Japan	128	76
South Korea	132	29
Singapore	217	196

Note. Data source: Jaafar, 2000.

Lifelong Learning

With knowledge replacing physical and natural resources as the key ingredient in economic development, education and HRD policies must be given due priority. The approach to HRD must be balanced and holistic. There must be a genuine partnership among government ministries, especially the Human Resource and Education Ministries, and between the private and public sectors to strategize and implement a human resource policy that is directed towards fulfilling the objectives of a k-economy (Badawi, 2000). Because economic development is now more dynamic than ever due to rapid technological improvements and global competition, the skills needed to succeed in this new economy will be different. Few will be able to equip themselves with lifetime working skills just from their years of formal education.

Lifelong learning conducted through nonformal channels such as virtual universities and distance learning, with skill acquisition at all age levels, must be promoted if the human resource is to constantly stay abreast of new and rapid development in the k-economy. In the context of HRD, Malaysia needs to adopt a two-pronged strategy (Badawi, 2000). One is to ensure that those who are currently unskilled or low skilled are given the opportunity to learn and train so that they can have a productive role in the k-economy. And second, incentives and opportunities must be given to those with the potential to keep on acquiring knowledge and skills. HRD must move every Malaysian up the skill ladder, and at the same time reward excellence by allowing all individuals to fulfill their potential. If the school and training systems fail to train and retrain the traditional workers, their existing skills may become obsolete in the new economic environment. If those with minimal education, knowledge, or skills are not given the opportunity to continue their education, they will lag behind and will be less likely to participate in the k-economy. Indirectly, the government will lose precious human capital that could have been harnessed effectively into a new economic paradigm. Therefore, HRD must be geared toward providing every citizen an opportunity to contribute at his or her optimum level.

It is evident that the Malaysian government is committed to building a critical mass of “knowledge” workers. Already under consideration are plans to build more advanced technical-industrial training institutes and community colleges in addition to the establishment of more "second route" programs to provide school leavers the opportunity to learn new skills. There is also a need for greater alliances between universities and the private sector to encourage industrial placements and internships. Greater attention must also be given to training workers in the small and medium industries (SMI). Most of the SMI firms can't afford to invest in training, retraining, and R&D.

Therefore, public sector HRD initiatives must prioritize SMI workers who have minimal opportunities to enhance their skills by their employers. At the same time IT training must be promoted, especially among working adults, to increase IT literacy among the workforce. School teachers should be given incentives to continue to upgrade their IT skills in light of the primacy of these tools in the k-economy. Civil servants and servicemen should also be given this training so that they are able to be absorbed into the technology intensive private sector upon the completion of their service. ICT training should also be extended to nonworking adults such as the disabled, senior citizens, and housewives so that they can contribute to the k-economy as virtual home-based workers, offering services through virtual interfaces such as the Internet.

In recognizing that HRD is a critical factor in a k-economy, smart partnerships between the public and private sectors should be established. In particular, the private sector must play a greater role in technical and vocational training in order to complement the efforts of the government. The government should continue to assist the private sector in training and retraining workers, but there must be a continued commitment from employers to encourage and provide incentives for their workers to acquire new knowledge and skills.

What It All Means

Research has shown that employers perceive technical competency as the critical workforce literacy. Communication and interpersonal skills are also essential. Other skills include critical- and problem-solving skills, self-motivation, and management skills. However, to compete and survive in the era of a k-economy and globalization, a new set of workplace literacy is deemed necessary. The k-economy requires knowledgeable, skilled, dynamic, creative, and innovative human resources. In addition, the new global market calls for visionary leadership and the adoption and application of new management and organizational principles. The old command-and-control management system that many Malaysian organizations are used to may not work in a new competitive environment. Thus, education, training, and employment policies have to change. Employers need to recruit more "knowledge" workers for higher skills jobs. This requires the education system to produce graduates with relevant knowledge, critical skills, and proper attitudes. Teacher training programs must also undergo substantial transformation. To create a new kind of workplace literacy based on the k-economy, some of the recommendations include:

- Create a technology roadmap to search for "niche" technology for Malaysia.
- Identify future knowledge and competencies.
- Invest in human capital.
- Provide a world-class telecommunication system that is accessible to all at competitive prices.
- Create an information society for all, where every citizen can play an active role in the k-economy.
- Promote the use of information technologies in all sectors.
- Equip all schools with high-speed Internet connections and multimedia PCs in sufficient numbers.
- Adapt the school curriculum and train the teachers in IT.
- Provide opportunities for lifelong learning.
- Invest in extensive research and development in order to increase the country's competitiveness both regionally and internationally.
- Establish systematic R&D networks linking businesses, educational institutions, and research institutes.
- Recognize and reward individuals or industries that are involved in creative

and innovative work practices.

- Promote smart partnerships between the public and private sectors.

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References

Abdul Manab, N., & Othman, A. (1999, December). *The implementation of information and communication technology in nurturing smart school learning environment in Malaysia: The Tiger Web project.* Paper presented at the Malaysian Educational Research Association Conference, Melaka, Malaysia.

Badawi, A. (2000, September). Keynote address at the 4th national Smart Partnership Dialogue, Kuala Lumpur, Malaysia.

Bank Negara Malaysia. (2000). *Annual report 1999.* Kuala Lumpur, Malaysia: Author.

Brown, K. W. (1976). What employers look for in job applicants. *Business Education Forum, 30*(7), 7.

Carnevale, A. P., Gainer, L. J., & Meltzer, A. S. (1990). *Workplace basics: The skills employers want.* San Francisco: Jossey-Bass.

Custer, R. L., & Claiborne, D. M. (1995). Critical skills clusters for vocational education: The employers' perspective—replication study. *Journal of Vocational Education Research, 20*(1), 7-33.

Distler, J. A. (1993). *Attitudes and perceptions of Maryland's mid-shore employers toward vocational education and employment training programs.* Unpublished doctoral dissertation, Temple University, Philadelphia.

Economic Research Services Department. (2000, August). *Special economic issue.* Kuala Lumpur, Malaysia: Bumiputra-Commerce Bank.

Greenan, J. P., Wu, M., Mustapha, R. B., & Ncube, L. (1998). Attitudes and motivations of vocational teachers regarding program improvement. *Journal of Industrial Teacher Education, 35*(3), 6-23.

Govindan, K. (2000). *Globalization, k-economy, and the virtual state.* Paper presented at the 12th National Real Estate Conference, Kuala Lumpur, Malaysia.

Harris Education Research Center. (1991). *An assessment of American education: The views of employers, higher educators, the public, recent students, and their parents.* New York: Louis Harris & Associates.

Infosoc Malaysia. (2000). *Access and equity: Benchmarking for progress.* Kuala Lumpur, Malaysia: National Information Technology Council.

Jaafar, A. S. (2000, June). *K-economy: Issues and challenges.* Paper presented at the national seminar on strengthening the macroeconomic fundamentals of the Malaysian economy, Kuala Lumpur, Malaysia.

Jonassen, D. H. (1996). *Computers in the classroom: Mind tools for critical thinking.* Englewood Cliffs, NJ: Prentice-Hall.

Junge, D. A., Daniels, M. H., & Karmos, J. S. (1984). Personnel managers' perceptions of requisite basic skills. *The Vocational Guidance Quarterly, 33*(2), 138-146.

Lieberman Research Inc. (1989). *Business responses to education in America: A study conducted among the largest U.S. companies.* New York: Time.

Mohamed, A. H., Hasan, H., Dzakiria, H., & Kassim, A. (1999, October). *IT impact on schools: Overcoming barriers in integrating computers in the Malaysian primary schools.* Paper presented at the 10th Asian Workshop on IT, Bangi, Malaysia.

Murphy, C., & Jenks, L. (1983). Getting a job after college: What skills are needed? *Journal of Career Education, 10*, 80-93.

Mustapha, R. (1999). *The role of vocational and technical education in the industrialization of Malaysia as perceived by educators and employers.* Unpublished doctoral dissertation, Purdue University, West Lafayette, IN.

Mustapha, R., & Abdullah, A. (2000). School-to-work and vocational training in Malaysia. *International Journal of Vocational Education and Training, 8,* 67–87.

Organization for Economic Cooperation and Development. (1996). *The 1996 science, technology and industry outlook*. Paris: Author.

Passmore, D. L. (1994). Expectations for entry-level workers: What employers say they want. In A. J. Pautler (Ed.), *High school to employment transition: Contemporary issues* (pp. 23-29). Ann Arbor, MI: Prakken.

Secretary's Commission on Achieving Necessary Skills, U.S. Department of Labor. (1991). *What work requires of schools.* Washington, DC: U.S. Government Printing Office.

Schultz, T. W. (1963). *The economic value of education.* New York: Columbia University Press.

Zakaria, A. (1988). *Perceptions of industrial training and employability skills: A comparative study of the vocational school and the MARA vocational institute students in Malaysia.* Unpublished doctoral dissertation, University of Pittsburgh, Pittsburgh, PA.

Books Briefly Noted

Alexander, Brian (2003). *Rapture: A raucous tour of cloning, transhumanism, and the new era of immortality.* New York: Basic Books. ISBN 0-7382-0761-6, pb, $15.00.

Brian Alexander takes readers into the surprising stories behind cloning, stem cells, miracle drugs, and genetic engineering to show how the battle for the human soul is playing out in the broader culture—and how the outcome will affect each and every one of us. Rapture's Dickensian cast of characters includes the father of regenerative medicine, an anti-aging guru, and a former fundamentalist Christian and founder of the company that reportedly cloned the first human cell. This motley crew is in part being united by the force of the opposition: a burgeoning coalition of conservative Republicans, the Christian right, and the Greens—predicting impending doom should we become adherents of the new bio-utopian faith. The book is irreverent, shocking, and highly entertaining as it seeks to separate hype from reality.

Anderson, John D., Jr. (2004). *Inventing flight: The Wright brothers and their predecessors.* Baltimore, MD: The Johns Hopkins University Press. ISBN 0-8018-6875-0, pb, $18.95.

The invention of heavier-than-air flight craft counts among humankind's defining achievements. In this book, the renowned aeronautical engineer John D. Anderson, Jr., offers a concise and engaging account of the technical developments that help to explain the Wright brothers' successful first flight on December 17, 1903. While the accomplishments of the Wrights have become legendary, we do well to remember that they inherited knowledge of aerodynamics and considerable flying-machine technology. Beginning with the earliest attempts at flight, Anderson notes the many failed efforts. He tells the fascinating story of aviation pioneers such as Sir George Cayley who proposed the modern design of a fixed-wing craft with a fuselage and horizontal and vertical tail surfaces in 1799 and of William Samuel Henson who won a patent in 1842 but never flew. He also examines the crucial contributions of German engineer Otto Lilienthal to the science of aerodynamics. With vintage photographs and informative diagrams, *Inventing Flight* will interest anyone who has ever wondered what lies behind the miracle of flight.

Beattie, Andrew, Paul R. Ehrlich (2004). *Wild solutions: How biodiversity is money in the bank.* New Haven, CT: Yale University Press, 2nd edition. ISBN 0-300-10506-1, pb, $16.00.

In this fascinating and abundantly illustrated book, two eminent ecologists explain how the millions of species on Earth not only help keep us alive but also hold possibilities for previously unimagined products, medicines, and even industries. In an afterword written especially for this edition, the authors consider the impact of two revolutions now taking place: the increasing rate at which we are discovering new species because of new technology available to us and the accelerating rate at which we are losing biological diversity. Also reviewed and summarized are many "new" wild solutions, such as innovative approaches to the discovery of pharmaceuticals, the "lotus effect," the ever-growing importance of bacteria, molecular biomimetics, ecological restoration, and robotics.

Bergeron, Kenneth D. (2004). *Tritium on ice: The dangerous new alliance of nuclear weapons and nuclear power.* Cambridge, MA: The MIT Press. ISBN 0-262-52433-3, pb, $15.95.

This winner of the Gold Award in Political Science in 2002 is now in paperback. For more than 50 years after the start of the nuclear age, the U.S. followed a policy barring commercial nuclear reactors from producing the ingredients of nuclear weapons. But in the fall of 2003 all that changed when a power plant operated by TVA started making tritium for the Department of Energy at the same time producing electricity for the commercial grid. Tritium, a radioactive form of hydrogen, is needed to turn A-bombs into H-bombs, and the commercial nuclear power plant that was modified to produce tritium is of a type called "ice condenser." This book provides an insider's perspective on how this nuclear policy reversal came about, and why it is dangerous.

Bødker, Keld, Finn Kensing, Jesper Simonsen (2004). *Participatory IT design: Designing for business and workplace realities.* Cambridge, MA: MIT Press. ISBN 0262-02568-X, hc, $50.00.

The goal of participatory IT design is to set sensible, general, and workable guidelines for the introduction of new information technology systems into an organization. Reflecting the latest systems-development research, this book encourages a business-oriented and socially sensitive approach that takes into consideration the specific organizational context as well as first-hand knowledge of users' work practices and allows all stakeholders—users, management, and staff—to participate in the process. Drawing on the work of a 10-

year research program in which the authors worked with Danish and American companies, the book offers a framework for carrying out IT design projects as well as case studies that stand as examples of the process.

Broadbent, Marianne, Ellen Kitzis (2004). *The new CIO leader: Setting the agenda and delivering results.* Boston: Harvard Business School Press. ISBN 1-59139-57-1, hc, $35.00.

Two converging factors—the ubiquitous presence of technology in organizations and the recent technology downturn—have brought Chief Information Officers to a critical breaking point. Then can seize the moment to leverage their expertise into a larger and more strategic role than ever before or they can allow themselves to be relegated to the sideline function of "chief technology mechanic." Drawing on extensive Gartner, Inc. interviews and research with thousands of CIOs and hundreds of companies, the authors outline the agenda CIOs need to integrate business and IT assets in a way that moves corporate strategy forward. Dozens of case examples appear throughout the book including AXA, Banknorth, British Airways, Citigroup, Commerce Bank, Disney, SKF, Starwood, Unicef, and U.S. city and federal agencies.

Bunch, B. & Hellermans, A. (2004). *The history of science and technology: A browser's guide to the great discoveries, inventions, and the people who made them from the dawn of time to today.* Boston: Houghton Mifflin. ISBN: 0-618-22123-9, $40.00.

Have you ever wondered how bridges are built? Do you know what medical discoveries led to the introduction of vaccines and antibiotics? Do you know why PCR (polymerase chain reaction) is one of the pillars of the biotechnology revolution? *The History of Science and Technology* is the ultimate resource for answers to questions about the when, what, why, and how of science and technology.

This accessible reference work, organized within 10 major periods of history, is a comprehensive, chronological guide to the scientific discoveries and technological innovations from the earliest periods of recorded history into the 21st century.

With more than 7,000 concise entries in such fields as archaeology, biology, computers, food and agriculture, medicine and health, and transportation, the book covers trends, important breakthroughs, births, deaths, and other useful information. Features include:

- in-depth section introductions that place each epoch in context
- short essays on intriguing topics, such as the history of DNA, the transit of Venus, the nature of light, and the relationship between electricity and magnetism
- 300 brief biographies of such personalities in science and technology as Galileo, the first scientist of the scientific revolution, and Charles Babbage, designer of the first mechanical computer
- 300 black-and-white drawings and photographs

Most entries are cross-referenced so that the reader can easily trace connections over time. This arrangement allows the reader to choose between following the development of a specific field through history and focusing on the breadth of innovation during a certain period.

Browsable yet richly detailed, *The History of Science and Technology* is an invaluable desktop reference for general reader and educator alike.

Campbell-Kelly, Martin (2004). *From airline reservations to Sonic the hedgehog: A history of the software industry.* Cambridge, MA: The MIT Press. ISBN 0-262-53262-X, pb, $16.95.

From its first glimmerings in the 1950s, the software industry has evolved to become the fourth largest industrial sector in the U.S. economy. Starting with a handful of software contractors who produced specialized programs for a few existing machines, the industry grew to include producers of corporate software packages and then makers of mass-market products and recreational software. This book tells the story of each of these types of firms, focusing on the products they developed, the business models they followed, and the markets they served.

Cassidy, David C. (2004). *J. Robert Oppenheimer and the American century.* New York: Pi Press. ISBN 0-13-147996-2, hc, $27.95.

The story of J. Robert Oppenheimer, physicist extraordinaire and the man who led the scientific team for the Manhattan Project that built the atomic bomb, has fascinated many people. Award-winning author David Cassidy, using previously unexamined documents, presents for the first time an integrated and coherent account of the man within the context of the nation he loved and so profoundly affected. Cassidy has crafted a richly detailed, gripping, and nuanced look at the theorist who theorized about black holes, the humanist who read Sanskrit, the man who loved his family, and the statesman who confronted the hardest moral dilemmas and scientific problems of his age. The hidden story of the political and social forces that shaped the world in the 20th century is the rise of American science, and Oppenheimer was at its epicenter. His story is at the crux of America's astonishing rise to power and an insight into the technological progress of our nation.

Chadarevian, Soraya de, Nick Hopwood, Eds. (2004). *Models: The third dimension of science.* Stanford, CA: Stanford University Press. ISBN 0-8047-3971-4, pb, $24.95.

Now that "3-D models" are so often digital displays on flat screens, it is timely to look back at solid models that were once the third dimension of science. This book is about wooden ships and plastic molecules, wax bodies and a perspex economy, monuments in cork and mathematics in plaster, casts of diseases, habitat dioramas, and extinct monsters rebuilt in bricks and mortar. These remarkable artifacts were fixtures of laboratories and lecture halls, studios and workshops, dockyards and museums. Considering such objects together for the first time, this interdisciplinary volume demonstrates how, in research, as well as teaching, 3-D models played major roles in making knowledge. Accessible and original chapters by leading scholars highlight the special properties of models, explore the interplay between representation in two dimensions and three, and investigate the shift to modeling with computers. The book is fascinating reading for anyone interested in the sciences, medicine, and technology, and in collections and museums.

Clarke, David, Ed. (2005). *Theory of technology.* New Brunswick, NJ: Transaction Publishers. ISBN 0-7658-0844-7, pb, $29.95.

The history of technology is often troubled by good ideas that do not, for one reason or another, take off right away—sometimes for millennia. Sometimes, technology comes to a standstill, and sometimes, it even reverses itself. Thus, unlike science, which seems to proceed at a reasonable and calm rate, the progress of technology is difficult to theorize about. David Clarke brings together 10 authors from a range of disciplines who try to understand technology from a variety of viewpoints. These essays originally appeared in two issues of *Knowledge, Technology & Policy* in 2002 and 2003.

Eglash, Ron, Jennifer L. Croissant, Giovanna Di Chiro, Rayvon Fouché, Eds. (2004). *Appropriate technology: Vernacular science and social power.* Minneapolis, MN: University of Minnesota Press. ISBN 0-8166-3427-0, pb, $25.95.

From the vernacular engineering of Latino car design to environmental analysis among rural women, to the production of indigenous herbal cures—groups outside the centers of scientific power persistently defy the notion that they are merely passive recipients of technological products and scientific knowledge. This work is the first study of how such "outsiders" reinvent consumer products—often in ways that embody critique, resistance, or outright revolt.

Emsley, John (2004). *Vanity, vitality, and virility: The science behind the products you love to buy.* New York: Oxford University Press. ISBN 0-19-280509-6, hc, $28.00.

Acclaimed popular science writer John Emsley explains the nature and behavior of about 40 ingredients that play important roles in every aspect of modern living. There are chapters on cosmetics, foods, sex, hygiene, depression, and on four unexpected ways in which modern products improve our lives. So if you have ever asked yourself whether cosmetics can deliver what they promise, whether certain spreads really can reduce cholesterol, whether nitrates in water are a cause of cancer, or whether Prozac is as safe as they say, dive into *Vanity, Vitality, and Virility* and discover things you always wanted to know.