JOURNAL OF

# TECHNICAL AND VOCATIONAL EDUCATION

ISSUE - 7

1990

TECHNICAL TEACHERS TRAINING INSTITUTE

MADRAS

# CONTENTS

## EDITORIAL

We are happy to place before the readers, this seventh issue of the Journal, which includes a wide range of articles on various aspects of technical and vocational education.

Dr. David L. Passmore in his article on 'Economic Development and Employment', describes an analytical tool- Interindustry analysis – which deals with employment consequences of various economic development plans and outlines issues related to the co-ordination of employment, education and training with such plans.

In his article on 'Technical and Vocational Education in Nigeria: Prospects and Problems in a Declining Economy' Mr. Afugbuom E.C. examines the problems of implementing the new policies relating to technical and vocational education in Nigeria in the context of a declining economy and suggests measures to overcome them.

The article by Mr. David Chantrill on 'Need for Creativity and Innovation in Technical Education' refers to the increased interest in creativity and innovation in technical education in the Colombo Plan countries and discusses strategies for developing creative organisations and individuals.

In the article on 'The Effectiveness of Computer Simulation in Training Programmers for CNC Machining' Dr. Yen-Fei Hwang et al report the findings of a study concerning the effectiveness of micro-computer simulation in learning CNC programming skills and highlight the advantages of the simulation method.

Dr. Terry Lane, in his article on 'Deference to Sex: Perceptual Differences between Male and Female Technician Teachers', analyses the nature of sex 'bias' among the male and female technician teachers and suggests that low participation of women in technical education has more to do with female "deference" than with male "bias".

The article by Mr. S. Fujinawa on 'Establishing a New Specialised Course in Electro-Mechanics in Technical High Schools in Japan' reports the efforts of Japanese Technical High Schools to improve the school curricula by incorporating modern developments in electronics and its applications. He presents a plan for establishment of a course in Electro-mechanics for modernising technical high school curricula.

In his article on 'Subject-based Package Approach to Staff Development', Dr. B.G. Barki describes an innovative method to train technical teachers using a pre-prepared instructional package and reports the outcomes of a try-out of this method for training teachers of technician mathematics.

# Economic Development and Employment*

DAVID L PASSMORE

*ABSTRACT*

*The article describes an analytical tool - inter industry analysis - that allows examination of the employment consequences of various economic development plans. The description of the model for such analysis is followed by an application of the model to a hypothetical economy. The article concludes with a brief outline of some of the opportunities and issues that persist in the co-ordination of employment, education and training with economic development plans.*

## Introduction

The Primary aims of economic development strategies are to improve employment opportunities and, as a result, the economic well-being of people in geopolitical regions. Of course, economic development may not only create demand for human resources, but it may also require a proper quantity and quality of human resources even for implementation. Human resources are, then, both ends and a means for economic development. The purpose of this article is to describe an analytical tool, *interindustry analysis*, that allows examination of the employment consequences of various economic developmental plans. The results of interindustry analysis have direct implications for coordination of employment, education, and training policies with economic development efforts.

As a descriptive tool, interindustry analysis simply portrays complex production and consumption dependencies in an economy. As a tool for retrospective and prospective analysis of economies, the interindustry analysis model allows evaluation of the effects of actions or events such as policy changes (e.g., establishment of import tariffs on targeted commodities, investment in public works projects, or redirection of government spending) or calamities (e.g. war, epidemic of disease, or natural disaster). Interindustry analysis can also specify the number of workers in particular industries and occupations required to fulfill various economic . scenarios. In this manner interindustry analysis provides a means to evaluate the human resource implications of any action or event that could influence the performance of an economy.

* *An earlier version of this paper was presented as a major discussion paper at a May 1988 meeting of the University Council for Training and Development Research sponsored by the University of Tennessee and the Tennessee Valley Authority in U.S.A.*

This article is divided into three major sections - a description of the model for interindustry analysis; an application of the interindustry model to a hypothetical economy; and a brief outline of some of the opportunities and issues that persist in the coordination of employment, education, and training with economic development plans.

**Interindustry Economics**

Wassily Leontief (1936, 1941, 1946, 1951, 1953, 1966) received the Nobel Prize in economics for his work on interindustry economic analysis. In this section I, first, describe the orgins of the Leontief's model. Second, I outline the mathematics of the model. Third, I extend Leontief's interindustry model to estimate employment by industry and occupation. These topics are merely a prelude to the next major section of this paper in which I apply Leontief's model and its extensions to growth and change in a hypothetical economy.

*Origins*

Money flows. Each dollar paid to the baker for bread is spent, in turn, for salt, eggs, and flour. The mill from which the baker buys flour uses the baker's money to buy grain. A farmer grows the grain from seed, fertilizer, and fuel purchases from suppliers. The diesel fuel supplied to the farmer completes a long journey from below nomadic sands to refineries to supertankers to distribution points. Banks, insurers, and other services support these transactions. Wages paid to workers during these complex transactions are saved or are used to purchase goods and services for household consumption. Although the purchase of a loaf of bread is a small ripple of economic activity, ripple adds to ripple to create waves in an economy that significantly affect many industries and workers.

In the 1930's, Wassily Leontief employed an approach based on his and earlier economists' observations about economic interdependence in production. Leontief (1936) published a table showing the transactions between producing and purchasing industries in the United States economy. Moreover, he provided mathematical tools necessary to derive some astoundingly useful information from the transaction table. Leontief's method is called *interindustry analysis* because it portrays dependencies among industries. Sometimes Leontief's model is called *input-output analysis* because it shows the industrial input necessary to produce economic output

Interindustry transaction tables are available for approximately 80 national economies. Although the Japanese probably are the most sophisticated users of Leontief's models, interindustry analysis has been used routinely in highly developed countries—both those that engage primarily in central planning (Tremi, 1973) and those that rely chiefly on market mechanisms for the allocation of resources and for the distribution of income (Cazes, 1972). The United States Bureau of Labor Statistics applies Leontief's model to forecast economic and employment changes in the United States (Bureau of Labor Statistics, 1986). Developing countries have used interindustry analysis to guide investments for development (Economic Commission for Latin America, 1956). Input-output methods are commonly applied to the study of growth and change in regional economies (Hawlings, 1985). The research output pertaining to interindustry analysis is so large that the official bibliographic reference to the American Economic Association, *The Journal of Economic Literature*, assigns a special section to input-output analysis.

*Model*

Consider an economy with n industries, characterized as *I* producing industries and *J* purchasing industries *(I=J=n)*. Let X define a square n-by-n matrix with elements $x_{ij}$ denoting the dollar value of output of producing industry *i* purchased by the industry *j*. For example, the steel industry sells some of its output to the automobile industry. Diagonal elements of X contain the amount of output of industry *i* that it purchases to produce its own output. The steel industry, for instance, uses some of its own output. X is called an *interindustry transaction matrix* describing the processing sector of an economy.

An economy's gross national product (GNP), or final demand for goods and service in the economy, contains *p* expenditures in categories such as personal consumption, investment, net exports, government purchase of goods and services. Let G indicate an n-by-p matrix with elements $g_{ip}$ denoting the dollar value of industry *i* output that is not purchased by other industries in the processing sector of the economy, but goes directly to GNP category *p*. G is important because it reveals the priorities of a society for creation and use of its material products. Growth and change in the economy are evident in alterations to G. The sum of the rows of G is denoted as y, an *n*-length vector containing the dollar value of output from each of the *i* producing industries that goes to meet total final demand for goods and services. The sum of y is the total GNP of the economy.

Let x indicate an *n*-length vector with elements $x_i$ denoting the total output of industry *i*. Total industrial output is the sum of the producing industry's output sold to purchasing industries *plus* the producing industry's output that goes directly to meet final demand for personal consumption, investment, exports, and government purchases. In matrix notation:

$$x = X + y, \qquad (1)$$

The amount of output purchase by industry *j* from producing industry *i* is shown in the cells of X. The proportion of industry *j* output contributing to industry *i* output, $a_{ij}$, is computed from $x_{ij}/x_i$. Let A represent an *n*-by-*n* square matrix containing elements $a_{ij}$. Now, equation (1) is rewritten as:

$$x = Ax + y, \qquad (2)$$

showing that total output is the proportion of total industry output that is sold to other industries plus industry output that contributes to final demand. Elements of A are called technical coefficients, input coefficients, or coefficients of production.

A – that is, the relative proportions of inputs necessary to achieve a certain level of industry output – is assumed to be fixed, homogeneous, and linear. In other words, the mix of inputs for industry *i* is not expected to change (fixed), the same mix of inputs is needed by all firms in industry *i* (homogenous), and no economies or diseconomies of scale exist with changes in industry *i* output (linear). Moreover, it is assumed that there is zero elasticity of substitution between industry *i* inputs. This means that changes in the prices of industry *i* inputs do not lead to changes in the relative proportion of inputs from producing industries purchased by industry *i*. These assumptions require the input-output model considered in this paper to represent a static, open economic system. Relaxation of these assumptions produces a more realistic model of a dynamic, closed economic system, but the resulting interindustry model is more complex than I am prepared to present in this paper.

Technical coefficients are assumed to be fixed over the time interval the interindustry model portrays. Changes in the values of technical coefficients would indicate fundamental changes in the technology of industrial production. Rapid changes in coefficients may, however, portend severe shocks for an economy. For example, the oil crisis of the 1970's required swift alterations in the energy use in many industries and by consumers. Other oil and energy sources were frantically sought by producing industries and consumers. The "energy problem" was manifest in changes in technical coefficients that resulted from energy bottlenecks in producing and purchasing industries, with consequent restrictions in income, employment, consumption and total production. In practice, though, technical coefficients are relatively stable in actual transaction matrices in most economies. Inspection of interindustry transaction matrices for the United States between the mid-1940's and the 1980's would reveal remarkably little change in technical coefficients for many industries.

The central analytical question in interindustry analysis is: How much total output must be produced by the processing sector of the economy to meet final demand? Rearrangement of equation (2) to state interindustry transactions and total output in terms of final demand yields:

$$y = x - Ax. \quad (3)$$

Introduction of I, an *n*-by-*n* identity matrix, allows equation (3) to be arranged:

$$y = (I - A)x$$

and, then, solved for x through:

$$x = (I - A)^{-1}y, \quad (4)$$

where $(I - A)^{-1}$ is the inverse of the matrix formed by (I - A). This inverse often is called the *Leontief Inverse*, the elements of which indicate the total output requirements generated directly or indirectly for industry *i* by industry *j* for every dollar's worth of industry *i* output delivered to final demand. Said in another way, the Leontief Inverse shows how much x must increase to increase y by one dollar. The Leontief Inverse is the primary analytical product of interindustry analysis of an economy.

Actions or events can alter final demand in at least three ways. First, contributions to GNP can increase uniformly over industries (overall growth). Second, particular industries may contribute more heavily to GNP (change in pattern of GNP). Or, third, new priorities are evident when GNP is redistributed among the *n* industries and *p* expenditure categories (change in distribution of GNP). Real or proposed reorderings of GNP expenditures can be studied by answering mathematically a series of "what if" questions. For instance, what if a government shifts defense funds to support social programs? What if taxes on corporations or individuals are lowered? What if a government decides to provide tax relief to targeted industries or individuals? What if government revenue is redistributed from one region to another region? Each these changes has specific implications for matrix G and, subsequently, vector y.

A new vector of final demand $y^*$, can be calculated to reflect the altered priorities for final demand over expenditure categories. Substitution of $y^*$ into equation (4) yields a new total output vector, $x^*$, which shows the distribution of total output necessary to create a different amount and kind of final demand. Premultiplication of $x^*$ by A results in a new interindustry transaction table which shows the amount of interindustry transactions required to support the level and kind of final demand specified by $y^*$. Application of this technique requires translation of the policy under consideration into an explicit distribution of GNP. Examination of the new interindustry transaction table is required to determine whether the economy can actually support the kind and amount of change in GNP required. These methods have had broad application to a variety of practical problems. As an illustration, Leontief (1966, ch. 9 & 10) studied the economic effects of disarmament and the structure of American exports and imports (Leontief, 1966, ch 6) using these methods. This technique frequently is called *sensitivity analysis* because it allows study of the vulnerability of an economy to variations in the amount and distribution of final demand.

*Extensions to Employment*

Each industry has a production function—that is, a mix of land, capital, and labor produces the industry's output. Let $\theta$ indicate an $n$-by-$n$ diagonal matrix of labor input coefficients to production. Diagonal elements of $\theta$, $\theta_{ii}$, are calculated from $e_i/x_i$, where $e_i$ is the total employment in industry $i$. Labor input coefficients define the number of workers needed to produce one dollar's worth of total industrial output. Total employment by industry is not calculated in the interindustry model; rather, it is derived from independent sources such as statistical surveys.

Let M denote an $n$-by-$n$ matrix containing elements $m_{ij}$ which describe the number of workers required within industry $i$ so that industry $j$ can deliver a dollar's worth of output to final demand. M is calculated by postmultiplying the labor input coefficients by the Leontief Inverse, or:

$$M = \theta(I - A)^{-1} \qquad (5)$$

A matrix of total employment by indutry, MTOT, is derived by premultiplying final demand by M, or

$$MTOT = M\ Y, \qquad (6)$$

Where Y is an $n$-by-$n$ diagonal matrix with elements of the final demand vector, y, on the diagonal. **MTOT** shows the total employment directly and indirectly created by a particular pattern of final demand.

Employment within n producing industries by k occupations is displayed in matrix S, an $n$-by-$k$ matrix, with elements $s_{ik}$, calculated from:

$$S = RB, \qquad (7)$$

where R is an $n$-by-$n$ diagonal matrix with the row sums of **MTOT** on its diagonal elements and B is an $n$-by-$k$ matrix showing the percent distribution of employment in industry i and occupation k. Rows of B are known as the *occupational staffing pattern* for industry i. B is not calculated in the interindustry model; rather, it usually is determined through occupational employment surveys within industries. S shows the employment by industry and occupation that is required to produce a particular distribution of GNP.

Several other policy-relevant results can be dissected from S, which shows the occupational employment generated in every industry. First, the occupational employment generated by each industry, shown in matrix SB, is calculated from:

$$SB = MTOT' B, \qquad (8)$$

Where **MTOT′** is the transpose of MTOT. Matrix SB, then, shows how many workers in each occupation over all industries owe their jobs to a particular industry. Second, by letting BK denote an *n*-by-*n* diagonal matrix whose diagonal elements correspond to column k of B, *n*-by-*n* matrix SC(k) can be created, where:

$$SC(k) = MTOT' BK. \qquad (9)$$

There are *k* SC(k) matrices that show how many workers in a particular occupation owe their jobs to each of the output delivered by each industry to final demand. The SC(k) matrices are referred to as *occupational employment profiles*, and they contain a highly detailed description of the structure of demand for an individual occupation generated by a specified distribution of GNP.

The interindustry model and its extensions to employment estimation provide the tools to examine the sensitivity of employment by industry and occupation to fluctuations in the amount and kind of output delivered to meet final demand for goods and services. A new vector of final demand, $y^*$, can be established to conform to altered expenditure priorities. Substitution of $y^*$ into equation (6) yields a new MTOT matrix which shows the new total employment required to produce a different amount and kind of final demand. Carrying through calculations through equations (7), (8), and (9) allows estimation of total employment by industry and occupation (matrix S), occupational employment that each industry generates (matrix SB), and employment generated in a particular occupation by interindustry contributions to final demand (SC(k) matrices).

The extension of Leontief's model to the estimation of employment by industry and occupation is primarily the result of research by Bezdek (1974). I review elsewhere (Passmore, 1979b) studies that used interindustry analysis to examine the sensitivity of employment to actual or anticipated economic changes. Several summaries, though, may help the reader understand the usefulness of such studies for policy development and review:

> Bezdek and Hannon (1974) determined the employment effects of reinvesting the $5 billion (in 1975 dollars) Highway Trust Fund in the United States in six alternative programs: railroad and mass transit construction; educational facilities construction; waste treatment plant construction; law enforcement; national health insurance; and tax relief. They found that energy consumption would be reduced by shifting the Highway Trust Fund to spending in all of these categories, except in the case of tax relief. Total employment would be increased in all cases, with negative as well as positive effects on employment in particular industries and occupations.
>
> Bezdek (1972) analyzed the employment consequences of *Counter-budget* (Benson & Wolman, 1971), which was a broad plan presented by the National Urban Coalition for reordering national expenditure patterns

in the United States to emphasize social programs. Bezdek found that *Counter-budget* proposal would not be politically acceptable because it would decrease employment in many occupations. Moreover, some occupations experiencing severe shortages of labor would require unrealistically large increases of workers to meet the pattern of final demand implied by the *Counter-budget* proposal.

Because the proof of the pudding is in its taste, I present in the next major section of this article a demonstration of interindustry economics to simplified, hypothetical economic data.

## Tinkerland : An Application

So that the previous section of this paper becomes more than a collection of abstract accounting equations, I cast a hypothetical regional economy, which I call *Tinkerland*, in the interindustry economic framework in this section. First, I describe production, consumption, and employment in the economy. Second, I alter the status quo of the economy in four ways to determine the effects of reordering priorities for final demand on occupational employment in each industry.

### *Status Quo*

#### TRANSACTIONS

The regional *Tinkerland* economy contains five industries: mining; manufacturing; construction; business and repair services; and transportation. Workers are employed in six major groups of occupations based on the United States census occupational classification system (Bureau of the Census, 1981): managerial and professional specialty occupations; technical, sales, and administrative support occupations; farming, forestry, and fishing occupations; precision production, craft, and repair occupations; and operators, fabricators, and laborers. There are six destinations for final demand for goods and services produced by the five industries: households; state government; defense expenditures by the federal government; non-defense expenditures by the federal government; inter-regional exports; and foreign exports.

Transactions among *Tinkerland* producing and purchasing industries shown in Table 1 correspond to matrix X in the "Interindustry Economics" section of this article. The distribution of final demand over industries corresponds to matrix G. The total final demand column in Table 1 is vector y, and the total output column is x. The total output of the *Tinkerland* economy during 1988 was $500 million. Its gross regional product, the value of goods and services delivered to meet final demand in 1988, was $202 million. Therefore, *Tinkerland* actually produced more than two times its gross regional product. Households received 40.1% of *Tinkerland's* gross regional product. Almost 12% went to state government, 5.4% to federal defense expenditures, 13.9% to federal non-defense expenditures, 21.3% to inter-regional exports, and 7.4% to foreign exports.

Interindustry transactions in the processing sector of Table 1 show, for example, that mining sold $9 million worth of goods and services to construction; mining purchased $21 million of its own output. Mining was the largest contributor to *Tinkerland* gross regional product, accounting for $67 million of the $202 million (33.2%) that went to final demand.

Table 1

*Tinkerland Regional Input, Demand, and Output (Producers' Prices, $ Millions)*

| Producing Industry | Purchasing Industry | | | | | Final Demand | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Federal | | | | | |
| | Mining | Manu-facturing | Construc-tion | Business & Repair | Trans-port | House-holds | State | Defense | Non-Defense | Inter-Regional Exports | Foreign Exports | Total Final Demand | Total Output |
| Mining | 21 | 0 | 9 | 3 | 0 | 30 | 10 | 5 | 0 | 20 | 2 | 67 | 100 |
| Manufacturing | 1 | 8 | 7 | 29 | 0 | 25 | 5 | 2 | 0 | 15 | 8 | 55 | 100 |
| Construction | 3 | 20 | 0 | 50 | 7 | 5 | 1 | 4 | 4 | 3 | 3 | 20 | 100 |
| Business & Repair | 31 | 2 | 38 | 0 | 3 | 12 | 2 | 0 | 11 | 1 | 0 | 26 | 100 |
| Transport | 10 | 25 | 26 | 1 | 4 | 9 | 6 | 0 | 13 | 4 | 2 | 34 | 100 |

*Source:* Adapted from Hawlings (1985, Figure 3.2, p.25)

Also, mining has the highest percentage (67%) of its total output that went to final demand among all five *Tinkerland* industries.

The matrix of technical coefficients, A, for the *Tinkerland* economy, derived by dividing the total output of each producing industry into the amount purchased by other industries (including itself), is:

$$A = \begin{pmatrix} .21 & 0 & .09 & .03 & 0 \\ .01 & .08 & .07 & .29 & 0 \\ .03 & .20 & 0 & .50 & .07 \\ .31 & .02 & .38 & 0 & .03 \\ .10 & .25 & .26 & .01 & .04 \end{pmatrix}$$

The Leontief Inverse for the *Tinkerland* economy is computed by taking the inverse of

$$(I - A) = \begin{pmatrix} .79 & 0 & -.09 & -.03 & 0 \\ -.01 & .92 & -.07 & -.29 & 0 \\ -.03 & -.20 & 1.00 & -.50 & -.07 \\ -.31 & -.02 & -.38 & 1.00 & -.03 \\ -.10 & -.25 & -.26 & -.01 & -.96 \end{pmatrix}$$

which yields

$$(I - A)^{-1} = \begin{pmatrix} 1.33 & .05 & .18 & .15 & .02 \\ .23 & 1.17 & .30 & .50 & .04 \\ .40 & .36 & 1.41 & 82 & .13 \\ .58 & .19 & .61 & 1.38 & .09 \\ .31 & .41 & .48 & .38 & 1.09 \end{pmatrix}$$

$(I - A)^{-1}$ shows the dollar amount that had to be transacted between industries to deliver an additional dollar's worth of output to *Tinkerland* final demand.

How are elements in the Leontief Inverse for the 1988 *Tinkerland* economy interpreted? This inverse contains the output requirements generated directly or indirectly for indutry $i$ by industry $j$ for every dollar's worth of industry $i$ to final demand. In terms of the *Tinkerland* inverse, this means that, for example, mining had to produce $1.33 worth of output for itself for every $1.00 it delivered to final demand. For every $1.00 of manufacturing output going to final demand, manufacturing had to deliver 23¢ of its output to mining. For every $1.00 of construction output delivered to final demand for construction goods and services, construction had to produce 82¢ worth of output for business and repair services.

The Leontief Inverse displays the dependencies that existed in 1988 between industries in the *Tinkerland* economy as they interacted to fulfill the demand for goods and services delivered to categories of final demand. The implications are that more output is needed for all other industries if mining goods and services are in greater demand (perhaps more mining output is exported). Mining purchases goods and services from other industries, either directly or after they are processed by other industries, to produce its output. The web of interdependencies in an actual economy is especially gnarled because there are many more industries and categories of final demand than in *Tinkerland*. A real economy is like a big ball of tangled string-pull a loose end on one side, and another end wiggles on the other side of the ball. The lesson: A change in any part of an economy usually has repercussions for other parts of the economy.

LABOR FORCE

*Tinkerland* had 3 million people in its 1988 civilian, non-institutionalized population between the ages of 16 and 70 years. The 1988 labor force status of the *Tinkerland* population, according to standard labor force definitions applied in

| *Labour Force Status* | *n* | % |
|---|---|---|
| In the Labor Force (employed + unemployed) | 2,200,000 | 73.3% of the population |
| Employed | 1,900,000 | 63.3% of the population |
| Unemployed | 300,000 | 13.6% of the labor force |
| Out of the Labor Force | 800,000 | 26.7% of the population |

the United States (see Passmore, 1981), was as above.

People who are unemployed and out of the labor force represent a "reserve army" that could be enlisted to meet *Tinkerland's* needs for additional workers as a result of economic change, but, of course, some mismatch may exist between the human capital these people possess and any new labor needs in the regional economy.

*Tinkerland* industries vary in the amount of labor they need to produce a dollar's worth of output. Total output (matrix x in the section on "Interindustry Economics"), total employment, and labor input coefficients (diagonal elements of matrix θ) during 1988 for *Tinkerland's* five industries were:

EMPLOYMENT BY OCCUPATION AND INDUSTRY

The distribution of 1988 *Tinkerland* employment by industry and occupation is shown in Panel I of Table 2 (produced by computing matrix S described in the section on "Interindustry Economics"). The pattern of employment shown in Panel I was required to produce the amount and kind of final demand specified in Table 1. Occupational employment varied from a high in technical, sales, and administrative support occupations, in which approximately one-fourth of all workers were employed, to farming, forestry, and fishing occupations, which employed only one in every 20 *Tinkerland* workers. Mining, the reader will remember, contributed the greatest proportion of industrial output to total 1988 *Tinkerland* output; likewise, mining accounted for the

| *Industry* | *Output (1)* | *Employment (2)* | *Labout Input (2 + 1)* |
|---|---|---|---|
| Mining | $ 100,000,000 | 600,000 | .006 |
| Manufacturing | $ 100,000,000 | 400,000 | .004 |
| Construction | $ 100,000,000 | 300,000 | .003 |
| Business & Repair | $ 100,000,000 | 100,000 | .001 |
| Transport | $ 100,000,000 | 500,000 | .005 |
| | *Total* $ 500,000,000 | *Total* 1,900,000 | Total .019 |

Table 2

*Regional Occupational Employment Generated Within and By Tinkerland Industries*

| Producing Industry | Managerial/ Professional Specialty | Technical/ Sales/ Adminis-trative | Service | Farming/ Forestry/ Fishing | Precision/ Craft/ Repair | Operators/ Fabrica-tors/ Laborers |
|---|---|---|---|---|---|---|
| | Occupation (in thousands) | | | | | |
| | I.Generated Within Industries* | | | | | |
| Mining | 120 | 120 | 60 | 30 | 90 | 180 |
| Manufacturing | 40 | 120 | 80 | 10 | 300 | 120 |
| Construction | 90 | 90 | 30 | 22.5 | 30 | 37.5 |
| Business & Repair | 30 | 20 | 10 | 10 | 5 | 25 |
| Transport | 100 | 150 | 100 | 40 | 10 | 100 |
| Total | 380 | 500 | 280 | 112.5 | 165 | 462.5 |
| % | 20.0% | 26.3% | 14.7% | 6% | 8.7% | 24.3% |
| | II. Generated By Industries** | | | | | |
| Mining | 169.6 | 188.2 | 98.4 | 46.5 | 96.9 | 219.4 |
| Manufacturing | 72.3 | 134.1 | 82.7 | 21.7 | 30.4 | 114.7 |
| Construction | 45.5 | 53.9 | 26.4 | 13.1 | 15.1 | 37.1 |
| Business & Repair | 49.6 | 61.3 | 32.5 | 14.8 | 16.5 | 49.2 |
| Transport | 43 | 62.5 | 40 | 16.4 | .61 | 42.1 |
| Total | 380 | 500 | 280 | 112.5 | 165 | 462.5 |
| % | 20.0% | 26.3% | 14.7% | 6% | 8.7% | 24.3% |

*Matrix S **Matrix SB

most employment of any of the five industries. Business and repair services had the lowest number of workers in the *Tinkerland* economy during 1988.

The distribution of occupational employment within industries varied because industries required different mixes of skills to produce goods and services. For example, business and repair service and construction industries had a higher percentage of their total industrial employment employed in managerial and professional specialty occupations than did other industries. Operators, fabricators, and laborers composed a greater proportion of the work force in mining and manufacturing industries than in other industries. The interested reader can

*Employment Generated (in thousands)*

| *Industry* | *Within(1)* | *By(2)* | *2 ÷ 1* |
|---|---|---|---|
| Mining | 600 | 819.0 | 1.37 |
| Manufacturing | 400 | 455.9 | 1.14 |
| Construction | 300 | 191.1 | .64 |
| Business & Repair | 100 | 223.9 | 2.24 |
| Transport | 500 | 210.1 | .42 |
| | *Total* 1,900 | *Total* 1,900 | *Total* 1.00 |

calculate the occupational staffing pattern of each industry by dividing the number employed within each occupation in an industry by the industry's total employment.

The dependency of occupational employment on the amount of total output of each industry is striking. Entries in panel II of Table 2 show the number of jobs in each occupation that were generated by each industry (matrix SB in the section on "Interindustry Economics"). Comparison of panels I and II indicates that, for instance, although mining employed 120,000 people in managerial and professional specialty occupations (panel I), the industrial output of mining delivered to industries and to final demand generated jobs for 169,600 people in managerial and professional specialty occupations (panel II). In other words, mining generated employment for 49,600 more workers in managerial and professional specialty occupations in other industries than it employed itself. In terms of the entire 1988 *Tinkerland* economy, mining was a big player-it employed 600,000 people (sum over the mining row in panel I of Table 2), almost one-third of all *Tinkerland* workers. But, even more important is that mining production created jobs for 819,000 workers (sum over the mining row in panel II of Table 2) over all industries in the *Tinkerland* economy.

The comparison of the employment generated *within* and *by* each industry isolates sectors of employment dependencies in the 1988 *Tinkerland* economy as given above.

For approximately every 3 workers employed in mining, need was generated for at least one other worker in the 1988 *Tinkerland* economy. A remarkable finding is that business and repair service industries employed the lowest number of workers in the *Tinkerland* economy, but more than two workers in all industries are employed for every worker in the business and repair service industries.

Mining, manufacturing, and, especially, business and repair service industries created jobs outside their own industries. Obversely, the total industrial outputs of transportation and construction industries could only directly support the employment of approximately one of every two of their workers, and total employment in these industries, therefore, depended heavily upon the activity of the three other *Tinkerland* industries.

The dependence of employment in any single *Tinkerland* occupation on interindustry transactions can be demonstrated. For example, the interindustry pattern of employment for service occupations keyed to interindustry activity (matrix *SC(k)*, where k is service occupations; see section on "Interindustry Economics") was:

$$SC(\text{service}) = \begin{pmatrix} 5{,}358 & 1{,}214 & 796 & 386 & 2{,}084 \\ 158 & 5{,}163 & 592 & 103 & 2{,}254 \\ 220 & 483 & 843 & 122 & 969 \\ 227 & 1036 & 639 & 358 & 992 \\ 37 & 102 & 131 & 30 & 3{,}703 \end{pmatrix}$$

The rows of matrix *SC* (service) are producing industries, and the columns are purchasing industries. Over one-half of employment in service occupations was generated solely from the production of mining, manufacturing, and transportation goods and services for these industries' own consumption [{(5,358 + 5,163 + 3,703) ÷ 28,000} x 100]. Transportation's sales to mining (row 5, column 1) and to business and repair services (row 5, column 4) created less than 1% of all employment in service occupations [{(37 + 30) ÷ 28,000} x 100]. Mining's sales to transportation (row 1, column 5) and manufacturing's sales to transportation (row 2, column 5) accounted for about 15% of all service occupation employment [{(2,084 + 2,254) ÷ 28,000} x 100]. Other *Tinkerland* occupations exhibit dependencies on interindustry transactions that can be revealed through similar matrices.

Results of descriptive interindustry analysis of the *Tinkerland* economy have value for formation and analysis of policy for employment, education, and training. On the employment side, information in Tables 1 and 2 clearly links production, consumption, and employment in *Tinkerland*. In particular, panel II of Table 2 highlights industrial sectors from which investments in growth and development might yield a high return of jobs. In the education and training dimension, information in panel I of Table 2 shows the demand for occupations to which education and training institutions supply labor. Panel II of Table 2 shows how increases in industries, seemingly unrelated to target industries of the training institutions, can affect the demand for occupations to which these institutions supply labor. The role of occupational supply in these planning problems is explored briefly in the next section of this article. My colleagues and I have offered elsewhere reports of the uses of interindustry analysis to plan education and training (see Passmore, 1979b, Passmore & Marron, 1978, 1982, Passmore, Marron, Hamil, & Fowler, 1979, Passmore, Marron, Norton, & Mohamed, 1983, Passmore & Martin, 1977) and of research on occupational supply to plan education and training (see Marron & Passmore, 1979, Passmore, 1979a, in press). The next frontier, though, is to use the results of interindustry analysis to determine the sensitivity of occupational employment by industry to planned or anticipated changes in the economy.

### *Changes*

What would happen to the amount of occupational employment by industry if *Tinkerland's* priorities for final demand changed? The effects of four *Tinkerland* scenarios are considered. First, I estimate the employment effects of relocation of a major manufacturing concern into *Tinkerland*. Second, infusion of government revenues for improvements in *Tinkerland's* infrastructure is studied. Third, shifts in federal spending from defense to non-defense expenditures in the *Tinkerland* economy are considered. Fourth, I simulate the employment effects of *Tinkerland's* involvement in a high technology adventure similar to that required to implement the United States government's plans for a Strategic Defense Initiative.

Each of the scenarios involves changes in the amount and distribution of final demand in the *Tinkerland* economy. Other factors could affect *Tinkerland* employment, but they are not examined in this paper. For instance, I do not allow for natural economic growth and change beyond the scenarios considered. Of course, these would be expected in any economy. Also, total employment and the amount and distribution of employment over industries are affected by changes in labor input co-efficients (diagonal elements of matrix θ), which would reflect changes in the productivity of labor in industries. Changes in the occupational staffing pattern within industries (changes in the percent distribution of occupational employment in industries) probably would go hand-in-hand with changes in labor productivity. Some occupations would need relatively more or fewer workers per dollar of total output if technology changed within an industry. Or, perhaps change in technology might create a new occupation and make redundant an existing occupation. Also, fundamental changes in interindustry transactions, manifest in changes in matrix A, could occur from changes in the production functions of industries, resulting in changes in economic structure and patterns of employment. Indeed. *Tinkerland* is a hypothetical economy.

RELOCATION

A toy manufacturer is evaluating whether one of its plants should be relocated during January 1989 to some fallow, inexpensive *Tinkerland* airport hanger space. If this relocation occurs, the contribution of manufacturing to final demand for manufacturing goods and services will increase by 20%. Some of the increased manufacturing output would be purchased by local households from a factory outlet. However, most of the toys made by the new plant would be exported to other regions and to foreign markets. As displayed in panel I of Table 3., the relocation of the toy manufacturing facility would add 95,327 jobs. Occupations within manufacturing industries would reap the greatest share of this increase, although jobs would be created in varying numbers in all *Tinkerland* industries and occupations.

Can *Tinkerland* sustain the job growth implied by the plant relocation? The answer to this question depends largely on the supply of labor in each occupation that is available to *Tinkerland* employers, a topic described encyclopedically by Sommers (1974). Perhaps some of the unemployed in the *Tinkerland* economy can fulfill the need for new workers; may be some people who are out of the labor force can be stimulated to seek work. Or, perhaps some workers will migrate into the *Tinkerland* region because of the new work opportunities it affords. Whether the new workers will need training before they can be productive is an additional crucial

Table 3

*Changes in Status Quo Occupational Employment by Industry for Four Tinkerland Economic Scenarios*

| Producing Industry | Employment Change from Status Quo | | | | | |
|---|---|---|---|---|---|---|
| | Managerial/ Professional Specialty | Technical/ Sales/ Administrative | Service | Farming/ Forestry/ Fishing | Precision/ Craft/ Repair | Operators/ Fabricators Laborers |
| | | | *I. Relocation* | | | |
| Mining | 622 | 622 | 331 | 166 | 497 | 922 |
| Manufacturing | 5,406 | 16,218 | 10,812 | 1,352 | 4,055 | 16,218 |
| Construction | 3,712 | 3,712 | 1,237 | 929 | 1,237 | 1,547 |
| Business & Repair | 645 | 430 | 215 | 215 | 107 | 538 |
| Transport | 4,716 | 7,075 | 4,716 | 1,887 | 472 | 4,716 |
| *Total* | 15,101 | 28,057 | 17,311 | 4,549 | 6,368 | 23,941 |
| | | | *II. Improvements to Infrastructure* | | | |
| Mining | 4,621 | 4,621 | 2,310 | 1,154 | 3,465 | 6,930 |
| Manufacturing | 2,535 | 7,602 | 5,068 | 634 | 1,901 | 7,602 |
| Construction | 26,564 | 26,564 | 8,854 | 6,641 | 8,854 | 11,068 |
| Business & Repair | 3,853 | 2,569 | 1,284 | 1,284 | 642 | 3,210 |
| Transport | 10,178 | 15,268 | 10,178 | 4,072 | 1,018 | 10,178 |
| *Total* | 47,751 | 56,624 | 27,694 | 13,785 | 15,880 | 38,988 |
| | | | *III. Shift to Social programs* | | | |
| Mining | 444 | 444 | 222 | 111 | 333 | 665 |
| Manufacturing | 243 | 726 | 485 | 61 | 182 | 727 |
| Construction | 2,516 | 2,516 | 838 | 629 | 839 | 1,048 |
| Business & Repair | 367 | 245 | 122 | 122 | 61 | 305 |
| Transport | 970 | 1,456 | 970 | 389 | 97 | 970 |
| *Total* | 4,540 | 5,387 | 2,637 | 1,318 | 1,512 | 3,715 |
| | | | *IV. High Technology Initiative* | | | |
| Mining | 2,654 | 2,654 | 1,327 | 664 | 1,990 | 3,979 |
| Manufacturing | 3,236 | 9,707 | 6,472 | 809 | 2,427 | 9,707 |
| Construction | 11,236 | 11,236 | 3,745 | 2,809 | 3,745 | 4,658 |
| Business & Repair | 6,231 | 4,154 | 2,077 | 2,077 | 1,039 | 5,193 |
| Transport | 5,934 | 8,902 | 5,934 | 2,374 | 594 | 5,844 |
| *Total* | 29,261 | 36,653 | 19,555 | 8,733 | 9,795 | 29,381 |

planning factor for education and training institutions in the *Tinkerland* region.

IMPROVEMENTS TO INFRASTRUCTURE

*Tinkerland* politicians believe strongly that the region's future depends upon refurbishing *Tinkerland* highways so that potential industrial investors can count on a sturdy infrastructure to transport their goods and services to markets. A rider to the Swamp Clearance Act of 1988 requires investments of $75 million in 1989 into the *Tinkerland* economy for highway construction. The rider requires contracts for highway construction to be let only to established *Tinkerland* contractors. In a press release, the government announces that, "This Act will create construction jobs for many people in *Tinkerland*". How many and what kind of jobs? Certainly, non-defense federal expenditures will absorb the increased construction output. Without any special analysis, it is clear intuitively that the rider to the Swamp Act will add even more pressure to the construction sector of the *Tinkerland* economy than is likely to occur naturally.

Panel II of Table 3 contains the occupational employment implications of the Swamp Clearance Act of 1988 for the *Tinkerland* economy. Employment must increase by 200,722 workers to produce the industrial output implied by the Act. Occupational employment in the construction industry would shoulder 45% of the increase in the number employed, although, as in the previous scenario, all occupations and industries would require increased employment. So, the ripple effects of the Act actually will yield more employment than originally. And, again, the next question for *Tinkerland* planners to consider is whether the necessary labor can be supplied to meet the employment demands created by this legislative action.

SHIFT TO SOCIAL PROGRAMS

*Guns versus butter...* the textbook economic trade-off. *Tinkerland* politicians have begun to wonder whether a new United States President after the election of 1988 will create a change in priorities for federal expenditures. Some of the politicians believe that the United States is heading for an administration that will spend more on butter, in the form of social programs, than on guns, in the form of defense expenditures. In fact, some *Tinkerland* politicians are optimistic that a veritable river of butter will flow, some of which eventually will trickle into the *Tinkerland* economy. Just what is in it for *Tinkerland*?

*Tinkerland's* politicians believe that 20% ($2 million) of amount of 1988 federal defense expenditures in *Tinkerland* will be reallocated immediately after the new President of the United States takes office in January 1988. Simple reallocation of total defense expenditure to total non-defense expenditures would not, however, create any changes in total employment by industry or occupation because no changes in total output by industry would occur. Of course, much of the industrial output for defense (tanks, guns, etc.) does not have a (legal) domestic market. So, 90% of the 20% reallocated federal defense expenditures would be distributed to the federal non-defense category for purchase or construction of low-income housing. The remaining 10% would be redistributed to households in the form of tax relief.

Panel III of Table 3 shows the employment effects of the guns/butter trade-off envisioned by *Tinkerland* politicians. The "river" envisioned by the politicians is a trickle, indeed 19,109 new jobs would be created. Although this amount of increase is small compared with the previously considered scenarios, it may actually be a more sustainable increase when factors related to the supply of labor are weighed.

HIGH TECHNOLOGY INITIATIVE

There is, certainly, a chance that the United States government may continue to purchase even more guns than butter if the Strategic Defense Initiative (popularly known in the United States as *Star Wars*) continues. *Tinkerland* defense contractors in manufacturing and business and repair industries will benefit from increased federal defense spending on Star Wars. What would the employment effects of 25% increase of federal government purchase of defense goods and services from *Tinkerland* manufacturing and business and repair services?

Panel IV of Table 3 shows the occupational employment by industry that would be required to support the increased federal defense expenditures in *Tinkerland.* An additional 133,378 workers would be needed to support Star Wars purchases in the *Tinkerland* economy. Over one-half of these increases will occur in construction and business and repair service industries, but substantial employment growth will occur in all industries and occupations.

ISSUES AND OPPORTUNITIES:

Implementation of the ideas in this paper is not without its difficulties. Strategic planning of employment, education, and training for economic development requires knowledge of the amounts and kinds of labor needed to fulfill economic development plans and of the employment results of the plans. Moreover, knowledge is needed about if and how human capital can be supplied to meet the demand for labor that the economic development would create. Policies guiding employment, education, and training must be informed, then, by more than information about labor demand. Detailed information about sources of the supply of labor in particular would help planners decide whether training actually is necessary to create the human capital needed.

Unfortunately, the study of occupational supply is sorely underdeveloped. More work is needed on the functional classification of occupations (see Scoville, 1969, for an analysis of problems that still persist). Descriptive and functional analyses of occupational supply are, pardon the pun, in short supply. Studies of the homogeneity and determinants of occupational staffing patterns and of labor input co-efficients need to be integrated into analysis of the supply of human resources.

Some readers might evaluate the focus on interindustry economics in this article as a technical solution to what is essentially a non-technical, moral, ideological problem in modern societies-that of providing fulfilling work and sufficient income for all citizens. Now, I do not propose use of interindustry analysis as a quick fix for economic and employment problems. Rather, I merely believe that many of the sincere hopes and vague plans offered for developing economies would be less vacuous if policy-makers were better informed about the direct and indirect economic and employment consequences of various development schemes. Upon close scrutiny, some of these schemes just are not possible because they are inconsistent with the resource base of the economy. Some of these schemes just are not desirable because they produce unintended and undesirable consequences. If loud talk, hard politics, and dogged work were enough, then these schemes would be successful. Unfortunately, the economic facts of life often and inconveniently intervene. The interindustry analysis methods I described in this paper are within our technical capability. They are simple to understand. And, they make the explicit connections-currently unfathomable, it seems, to many people-between what we produce, what we buy, and the jobs that are created as a result.

## REFERENCES

BENSON, R. S., & WOLMAN, H. (1971). *Counterbudget: A blueprint for changing national priorities*. New York, NY: Prager.

BEZDEK, R. H. (1972). The employment effects of *Counterbudget*. *Journal of Economic Issues*, 6(4), 171-186.

BEZDEK, R. H. (1974). *The long-range forecasting of manpower requirements*. New York, NY: IEEE Press.

BEZDEK, R. H., & HANNON, B. (1974). Energy, manpower, and the Highway Trust Fund. *Science*, 185, 669-675.

BUREAU OF THE CENSUS, United States Department of Commerce. (1981). *1980 census of the population: Alphabetic index of industries and occupations*. Washington, D.C.: United States Government Printing Office.

BUREAU OF LABOR STATISTICS, United States Department of Labor. (1986). *Employment projections for 1995: Data and methods*. Washington, D.C.: United States Government Printing Office.

CAZES, B (1972). Future research and economic planning: The French case. *Economic Planning*, 12(1-2), 115-129.

ECONOMIC COMMISSION FOR LATIN AMERICA, United Nations. (1956). The input-output model. *Economic Bulletin for Latin America*, 1(2), 16-28.

HAWLINGS, G. J. D. (1985). *Regional input-output analysis*. Beverly Hills, CA: Sage Publications.

LEONTIEF, W. (1936). Quantitative input-output relations in the economic system of the United States. *The Review of Economics and Statistics*, 43, 105-125.

LEONTIEF, W. (1941). *The structure of the American economy, 1919-1939*. New York, NY: Oxford University Press.

LEONTIEF, W. (1946). Exports, imports, domestic output, and employment. *Quarterly Journal of Economics, 60(2)*, 171-193.

LEONTIEF, W. (1951). *The structure of the American economy, 1919-1939*. New York, NY: Oxford University Press.

LEONTIEF, W. (1953). *Studies in the structure of the American economy*. New York, NY: Oxford University Press.

LEONTIEF, W. (1966). *Input-output economics*. New York, NY: Oxford University Press.

MARRON, M., & PASSMORE, D.L. (1979). Occupational supply information for planning education for work. *Journal of Industrial Teacher Education, 17(1)*, 39-56.

PASSMORE, D.L. (in press). The occupational supply structure of the firm *Occupational Education Forum.*

PASSMORE, D.L. (1979a). The book-keeping occupation: What does the future hold? *Journal of Studies in Technical Careers, 1(2)*, 162-171.

PASSMORE, D.L. (1979b). Use of interindustry analysis to plan education for work. *Journal of Industrial Teacher Education, 17(1)*, 7-24.

PASSMORE, D.L. (1981). Measuring youth joblessness: Concepts, tools, and issues. *Journal of Studies in Technical Careers*, 3(2), 109-125.

PASSMORE, D.L., & MARRON, M. (1978). *Expected employment outcomes from educational programs of the National Technical Institute for the Deaf* (Division of Management Services Report No. 20). Rochester, NY: National Technical Institute for the Deaf at the Rochester Institute of Technology.

PASSMORE, D.L., & MARRON, M. (1982). Stating expected employment outcomes of occupational programs: A case study. *Journal of Studies in Technical Careers*, 1 (1), 13-26.

PASSMORE, D.L., MARRON, M., HAMIL, F., & FOWLER, M. (1979). *National employment outlook for medical record technicians* (Division of Management Services Report No. 29). Rochester, NY: National Technical Institute for the Deaf at the Rochester Institute of Technology.

PASSMORE, D.L., MARRON, M., NORTON, W.P., & MAHAMED, D.A. (1983). National employment outlook for medical record technicians. *Journal of Studies in Technical Careers*, 5(1), 27-34.

PASSMORE, D.L., & MARTIN, K.M. (1977). *National employment outlook in bookkeeping occupations* (Division of Management Services Report No. 6). Rochester, NY: National Technical Institute for the Deaf at the Rochester Institute of Technology.

SCOVILLE, J.C. (1969). *The job content of the U.S. economy*. New York, NY: MoGraw-Hill.

SOMMERS, D. (1974). *Occupational supply: Concepts and sources of data for manpower analysis* (Bureau of Labor Statistics Bulletin 1816). Washington, DC: United States Government Printing Office.

TREML, V.G. (1973). *Input-output analysis in the U.S.S.R.: An annotated bibliography*. Durham, NC: Center for International Studies, Duke University.

# Technical and Vocational Education in Nigeria: Prospects and Problems in a Declining Economy.

AFUGBUOM E.C.

*ABSTRACT*

*This paper examines the new Nigerian National Policy on Education as it affects the technical and vocational education system in the country. Some of the problems of implementing the new policy, especially in the context of a declining economy, are highlighted and recommendations for its effective implementation are provided.*

## Introduction

Education has for long, assumed a predominant position in national development, not in Nigeria alone, but all over the world. Nigeria, in particular, has long recognized the importance of education in the economic and social development of the country. This can be seen from her development plans and subsequent annual budgets, where, in most cases. education takes the lion's share.

The economic problems of Nigeria which extend to eduction, thereby giving birth to the notorious crisis within it, have roots in the pattern and structure of government's expenditure for nearly two decades. Prior to the advent of the oil market in the seventies, the Nigerian economy was fairly robust and flexible enough to sustain it against fluctuations and economic misfortunes. But when the oil sector shot into prominence in the 1970's resulting in the frivolous days of the oil boom, Nigeria embarked on ambitious educational expansion and gigantic programmes such as the U.P.E. scheme, whose design and scope bore no relationship to the need or resource base of the economy.

Educationally, the oil boom period proved regressive and detrimental to meaningful advancement in this sector. The concept of education was reduced to a paper–chase affair. Graduates went to school to pursue courses in sectors totally irrelevant to the manpower needs of the nation so long as such disciplines were shortcuts to prestigious jobs.

When the U.P.E. scheme prematurely collapsed, Nigeria's educational policy makers conceived and formulated, the New National Policy on Education in 1977. The New Policy otherwise known as the 6-3-3-4 system, is a dream come true and a landmark in Nigeria's quest for qualitative and functional education for making the citizens less dependent on government and reducing the government's burden. This paper tends to look at the new policy as it affects Technical and Vocational Education in Nigeria, what it set out to achieve, and the implementation problems especially during this period of declining economy.

## Technical and Vocational Education

The policy governing the present and future development of technical and vocational education in Nigeria as embodied in the New National Policy on Education defines Technical Education as "that aspect of education which leads to the acquisition of practical and applied skills as well as basic Scientific Knowledge". The aims and objectives of technical education in Nigeria are to (FME National Report, 1986: 19):

— provide trained manpower in applied science, technology and commerce particularly at sub-professional grades;

— provide the technical knowledge and vocational skills necessary for agricultural, industrial, commercial and economic development;

— provide people who can apply scientific knowledge to the improvement and solution of environmental problems for the use and convenience of man;

— give an introduction to professional studies in engineering and other technologies;

— give training and impart the necessary skills leading to the production of craftsmen, technicians and other skilled personnel who will be enterprising and self-reliant; and

— enable our young men and women to have an intelligent understanding of the increasing complexity of technology.

In order to achieve these objectives, technical and vocational subjects which were once taught in a relatively few special institutions have become part of general education. Technical, Commercial and Vocational subjects are now taught throughout the six-year secondary education of the newly introduced 6-3-3-4 education system. At the end of the three year junior secondary education, the students may choose to go to vocational centres or technical colleges to learn skills in arts and crafts or continue and complete the three years of Senior Secondary education with a view to pursuing further studies in University, Colleges of Technology, Polytechnics, Technical Teachers' Colleges and Colleges of Education.

The structure and content of Courses offered in technical colleges have been organized in a modular system which would guarantee that all essential practical skills are taught and learned, while at the same time allowing for each individual's training to advance at his or her own rate. The system of certification based on the criteria for City and Guilds of London Institute has been almost completely replaced by School Certificate (Technical) awarded by the West African Examination Council (WAEC).

Sample of a programme in modules is as under:

| Programme | Modules of Employable skills |
|---|---|
| Mechanical Engineering | Fitting |
| | Turning and lathe work |
| | Milling machine |
| | Boring |
| | Inspection and measurement |
| | Press, Jips, and fixtures |
| | Tool and die making |
| | Drilling, planing and slothing |
| | Grinding |
| | Valves, Pumps and drive components. |

In full awareness that for an effective technical education teaching staff is an essential pre-requisite, the issue of production of technical and vocational teachers is a priority to the Nigerian Government. These teachers are being produced by Federal Colleges of Education (Technical) and other institutions of higher learning which include Colleges of Technology, Polytechnics and Colleges of Education at both Federal and State levels. Due to the demand for teachers for the technical and vocational components of the new secondary education structure, the Federal Government has decided to open six new Federal Colleges of Education (Technical).

In–service staff development programmes for technical instructors have been established at the national level in collaboration with international agencies and by bilateral agreements with other countries. Courses offered include:

— Management of technical and vocational institutions.

— Skills upgrading for technical teachers

— Audio visual-aids training

— Group training courses for vocational teachers.

**Implementation Problems**

The philosophical basis of the new policy is development of individuals into sound and effective citizens with provision of equal opportunity for all from primary up to the tertiary levels.

Nevertheless, the success of any system depends on proper planning, efficient administration and adequate funding. Robert McNamara, former President of the World Bank, once said

"Developing Countries have greatly expanded their educational system over the past quarter of the century. But much of the expansion has been misdirected resulting into one of the most disturbing paradoxes of our time. While millions of people are unemployed, millions of jobs are waiting to be done because people with the right education, training and skills cannot be found".

This candid comment of the learned economist, highlights a major problem of educational planning in Nigeria and most of the developing countries.

In Nigeria, for instance, lack of foresightedness, imprecise policy formulations, hasty ambitious planning and misdirected expansion constitute the major drawbacks of educational planning. When planning, possibility of changing circumstances are rarely taken into account. These and many administrative lapses, continue to hinder the development of qualitative and functional education in the country.

Halfway into the middle of the 1980's, Nigeria's economy deteriorated as a result of a drastic fall in the oil market. This ushered in the impending oil doom which extended to subsequent governments. As a result of this economic predicament, the Federal Government found it very difficult to adequately fund education at all levels. As Nigeria's economy suffers pathetic decline, the then Federal Government under the Shagari administration, came out with more stringent economic measures known as "austerity measures" – which were geared towards revitalizing the collapsing economy.

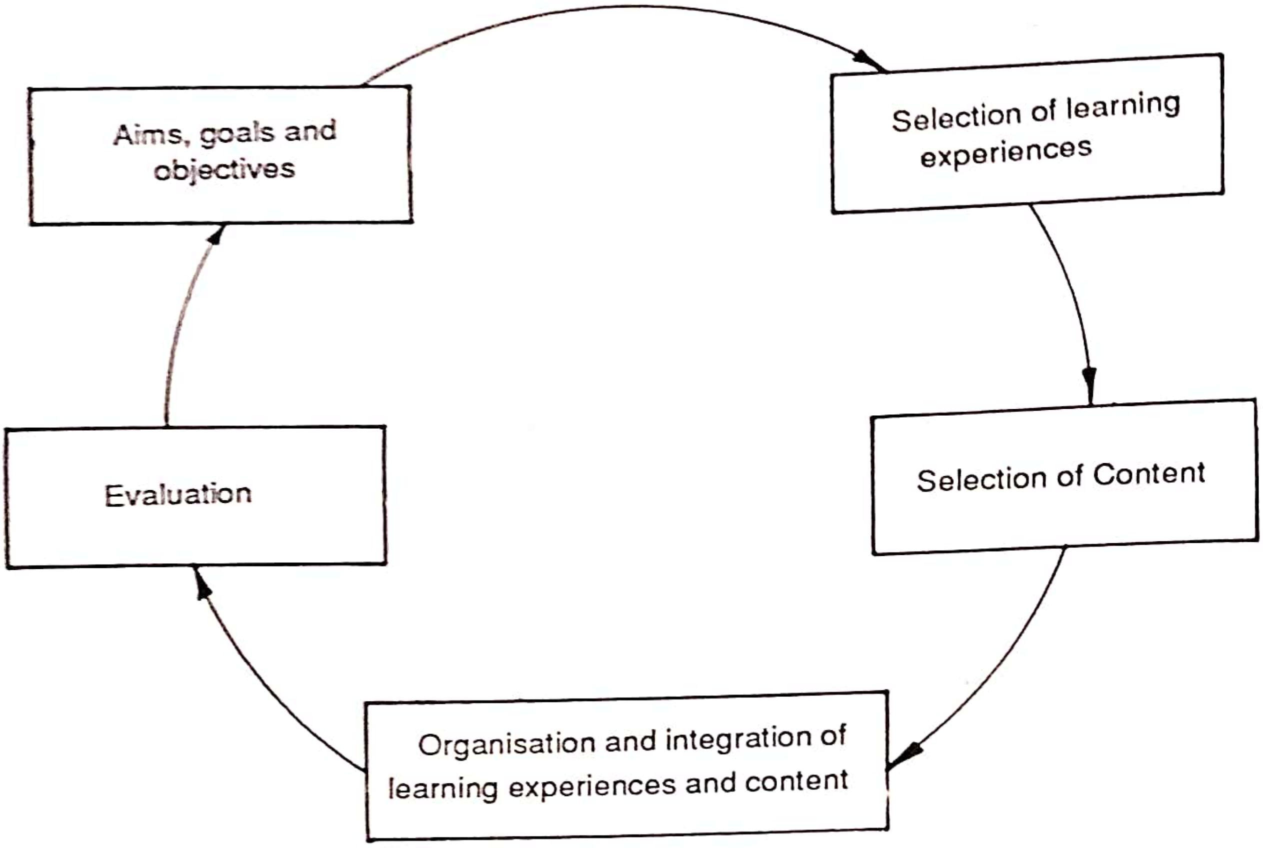
The weakening of resources continued into the subsequent Military Government. The Buhari/Idiagbon administration has not had better luck with regard to resources. However, they left no one in doubt with regard to the implementation of cost-saving devices towards proper direction of revising the policy. Nevertheless, it is now clear that the policy is almost beyond us.

As a result of all these acts of omission or commission which affected the policy immensely, proper implementation of the policy has eluded us. Right from the beginning, the Government committed itself by arrogating to itself the full responsibility of financing eduction at all levels, thereby motivating complete over-dependence on the government by the populace. This assertion is justifiable when we look on the first sentence which introduced the New National Policy on Education. This categorically declared that "Education in Nigeria is no more a private enterprise, but a huge government venture that has witnessed a progressive evolution of government's complete dynamic intervention and active participation". Based on this, one would say that government made only a vague reference to the question of encouraging all to share the responsibility of financing education.

Another problem which militates against the proper implementation of the new policy is the issue of raising additional resources to meet the demand of the policy. The enrichment of the secondary school curriculum has led to the emergence of some new subjects such as Introductory Technology. This is intended to make the child learn to use his head and hands, and also respect the dignity of labour. The implication of this is that a large number of instructional materials and qualified manpower are now required from overseas since Nigeria cannot produce enough. With current Structural Adjustment Programme (SAP) which encourages cost saving measures, money available can only provide very little. As a result of this economic programme which started with Second-Tier Foreign Exchange Market (SFEM) now FEM, the national policy suffered a lot of set-backs which, if appropriate care is not taken, will also follow the footsteps of the UPE scheme.

"Planning" Eduction under the current Structural Adjustment Programme has to be restructured to give room for proper implementation of the educational system. Nigeria, in the first place, should devise certain realistic measures that will enable our weak economy maintain the present educational system. The most nagging problem with Nigeria's education planners and policy formulators is that they are not taking pride in what they have. The question is: why should they go borrowing concepts from foreign countries? Although there is nothing wrong in borrowing what is good from another country, one has to be very careful and selective in borrowing, for it is not everything that is good in one country could be equally good for another. That is why the proponents of "cultural borrowing" in eduction headed by Brian Homes warned against borrowing dogmatically. Therefore, for the new policy on education to be effective, Nigerian policy formulators must take pride in originality.

As it is with all curriculum innovations, our hope for the overall success of the new policy on eduction rests on its being subjected to constant review using the cyclic process of curriculum




development long recommended by Wheeler (1967) as cited by Adeyegbe (1987). This is depicted above.

Constant review of what Halliwell (1972) terms 4A^s viz Aims, Actions, Assessment and Adjustment of the system, will safeguard our hopes as we live and grow with the system. If by our act of omission or commission, the new policy collapses, then on our epitaphs as teachers, curriculum experts, educational administrators, inspectors of eduction and government policy makers students of this generation may write:

> "Here lie the graves of the so-called experts, torch-bearers and innovators at the frontiers of knowledge who have prevented us from benefitting from the lofty ideals of the 6-3-3-4 educational system".

**Recommendations**

The following recommendations are provided for effectively implementing the new policy:

— The personnel sector should be re-structured. The system introduced a number of new elements which calls for the right calibre of teachers with the right skills and attitudes.

— Government should introduce apprentice system by employing local engineers such as road side mechanics and local electricians as practical instructors in our schools. This if effectively utilized will yield better and practical results.

— Government should involve all groups of people in the funding of education. Local Communities and private organizations should be mobilized for the purpose.

— Under current diminishing economy, private industrial organizations should be compelled to contribute their quota towards the development of Universities, Polytechnics, Colleges of Technology and Colleges of Education.

— Government should continue establishing centres for the design and manufacture of science equipment and other teaching aids locally. The government should pump enough funds to them to enable them come out with the necessary and relevant material needed for the implementation of the policy. This effort if supplemented will ease the difficulties of importing the equipments from overseas.

**Conclusion**

This new system of education, the secondary school component of which was launched in 1982, became necessary because of inherent deficiencies of the colonial system whose sole purpose was producing workers for white collar jobs. Such a system is totally inappropriate and inadequate today for developing countries like ours, since it cannot equip its products with the technological know-how for mastering their environment and surmounting the problems of underdevelopment. The major thrust of the Nigerian National Policy on Educlion is the functionality of its secondary education and the genuine opportunity provided to students for selection of subjects from a wide variety of offerings tailored to suit a wide range of abilities. The pre-vocational subjects are aimed at providing opportunity for students to learn subjects that could lead to self-reliance in employment, or to a profession where challenges for immediate contribution to the development of our society abound. Thus, it can be seen that the secondary school component of our new system of education has the cardinal advantages of enriched curricula, the building up of manipulative skills and the development of a technological culture, all of which are pre-requisites for a respectable and dignified entry into the 21st century.

Finally, one would like to caution our educational planners, policy makers and educational administrators once again that it is high time they placed adequate emphasis on national unity and excellence in scientific and technological progress. Nigeria is lagging behind in economic development, because we confer more priority on distribution of the national cake rather than baking it for self-reliance. The focus should be on effective implementation of the policy through the turbulent formative years ahead.

**REFERENCES**

ADEYEGBE, S.O. (1987), "The 6-3-3-4 National Policy on Education: Any hope for Nigeria?". *WAEC NEWS – A House Journal of the African Examinations Council* 3 (18) Sept/Dec. 1987.

FEDERAL MINISTRY OF EDUCATION (1981), "National Policy on Education" (Revised).

FEDERAL MINISTRY OF EDUCATION (1986), "Development of Education 1984-1986; National Report of Nigeria". International Conference on Education, 40th session, Geneva 1986, pp 19-43.

FEDERAL MINISTRY OF EDUCATION (1988), "Current Developments in Policies and Systems in Education in Anglophone West African Countries". International Conference, Ibadan, Nigeria 26th-30th Sept., 1988. *WAEC NEWS – A House Journal of the West African Examinations Council* 3(21); Sept/Dec. 1988.

MKPA, M.A. (1987), Curriculum, Development and Implementation. First Edition, Owerri: Totan Publishers Ltd.

MUNZALI, M. (1989), "6-3-3-4 in a Declining Economy" *New Nigerian*, June 24, 1989.

## Need for Creativity and Innovation in Technical Education

DAVID CHANTRILL

*ABSTRACT*

*This paper looks at technological changes taking place in many of the regional member countries of the Colombo Plan and examines their implications for technician educators. It suggests that the increased interest in creativity and innovation is consistent with the need to shift from an emphasis on teaching product skills to that of teaching process skills. Barriers to the development of creative and innovative skills are discussed and strategies for developing creative organisations and individuals are presented. The paper concludes with some thoughts on thinking and gives some guidelines to improve the clarity of thinking.*

### Introduction

The last few years have seen a growth of interest in the theme of developing creative and innovative skills and it is legitimate to ask ... why this sudden interest? Before I attempt to address this question it may be of value to explore the origins of this desire to stimulate creative and innovative behaviour.

For many years Switzerland has enjoyed a high reputation in terms of its creative and innovative approach to design of its established niche areas of manufacturing and this is particularly evidenced in its watchmaking industry. This industry has been able to maintain its competitive edge despite dramatic changes in quartz crystal technology. It is also interesting to note that this competitive edge has not been maintained by reducing price, but rather by an emphasis on quality and design. More recently, many industrialized countries look at Japan with a view to identifying the reasons behind its phenomenal industrial successes. Many serious students reach the conclusion that much of Japan's success is based on innovation as distinct from the creation of entirely new ideas and concepts. No doubt this situation is rapidly changing since Japan today does commit a huge amount of resources to research and development.

It is probably relevant at this point to make the distinction between creativity and innovation. Actually defining and distinguishing between these two terms is easier said than done; however, I have chosen the definitions given by Robert L.Kuhn[1] :

"CREATIVITY is the process by which novel ideas are generated."
"INNOVATION is the process by which those novel ideas are transformed into things tangible and useful."

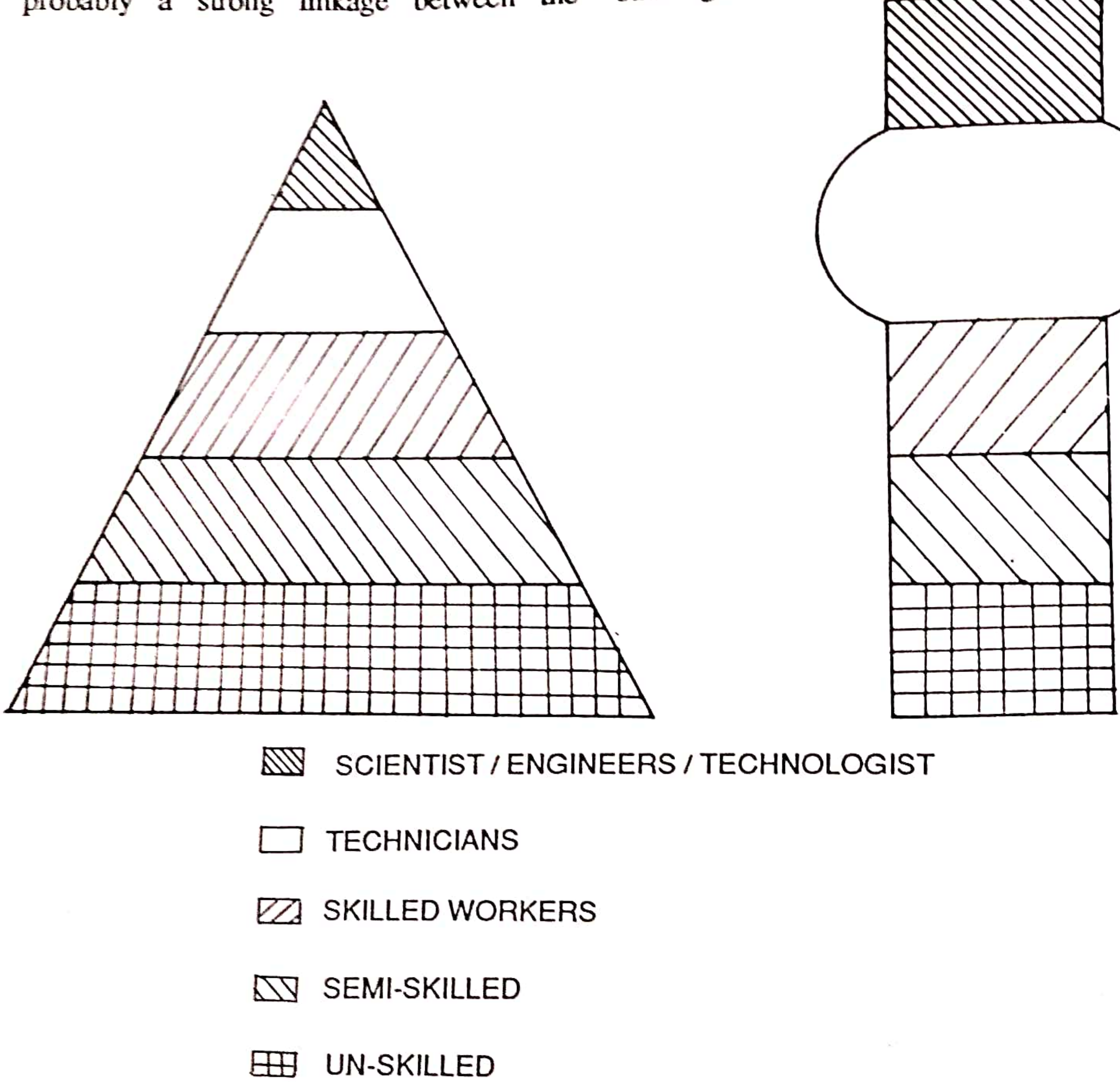
Incremental improvements in existing products are therefore viewed as "innovations". The use of quality circles results almost invariably in innovations.

One of the difficulties with most definitions is that it is not possible to say that things are either totally black or totally white and it could be argued that innovation requires an element of creative thinking. As Kuhn points out ... "Creativity without innovation is aimless, while innovation without creativity is sterile".

Getting back to the question that I opened up with, the key is really to maintain a competitive edge and creativity and innovation is a critical dimension of strategic planning and thinking. There is probably a strong linkage between the growth of interest in strategic planning and the development of a more creative and innovative workforce. Those industrialised countries who have moved away from labour – intensive to technology – intensive manufacturing need a different type of work force to survive and thrive.

**Rationale**

This shift away from labour–intensive to technology–intensive manufacturing may be simultaneously occuring in other sectors of the economy too, such as banking/financial services and service



industries. The logical question for educators to ask is ... what are the manpower implications of such changes? They are causing macro-level distortions to previous patterns of the manpower spectrum. Whereas one could once roughly describe the quantitative manpower spectrum in the form of a pyramid shape, now it is starting to look more like a "flower vase". This is illustrated in page 28.

These diagrams depict the *quantitative* shifts taking place in the workforce, but side by side there are significant *qualitative* shifts. The level of technology in the work place has risen dramatically as has the diversity. If one translates these shifts into training needs say at the technician level, then it is easy to reach the conclusion that traditional "one-shot" two/three courses which emphasise product skills, will become totally inadequate in a relatively short space of time. This necessitates radically different approaches to curriculum structure and design. Not only will the need for continuous education become stronger and stronger, but also the nature of technical education will need re-thinking. Today's and tomorrow's technicians need a much greater emphasis on the development of process skills, rather than product skills. The complexity and diversity of the technology that they are being asked to manage is such that they cannot hope to maintain their currency in terms of product skills, but the real contribution that they can make is by the application of more effective and efficient "thinking" skills. If one accepts that we are living in an ever-shrinking world in which protectionism will decline, then the key to any nation's economic success will be in its ability to maintain a competitive edge in niche areas of activity. The best resource any country has is its people and the key to economic success will increasingly be in the resourcefulness of the people. Their creativity, innovation and hardwork will provide the engine of growth.

## Barriers

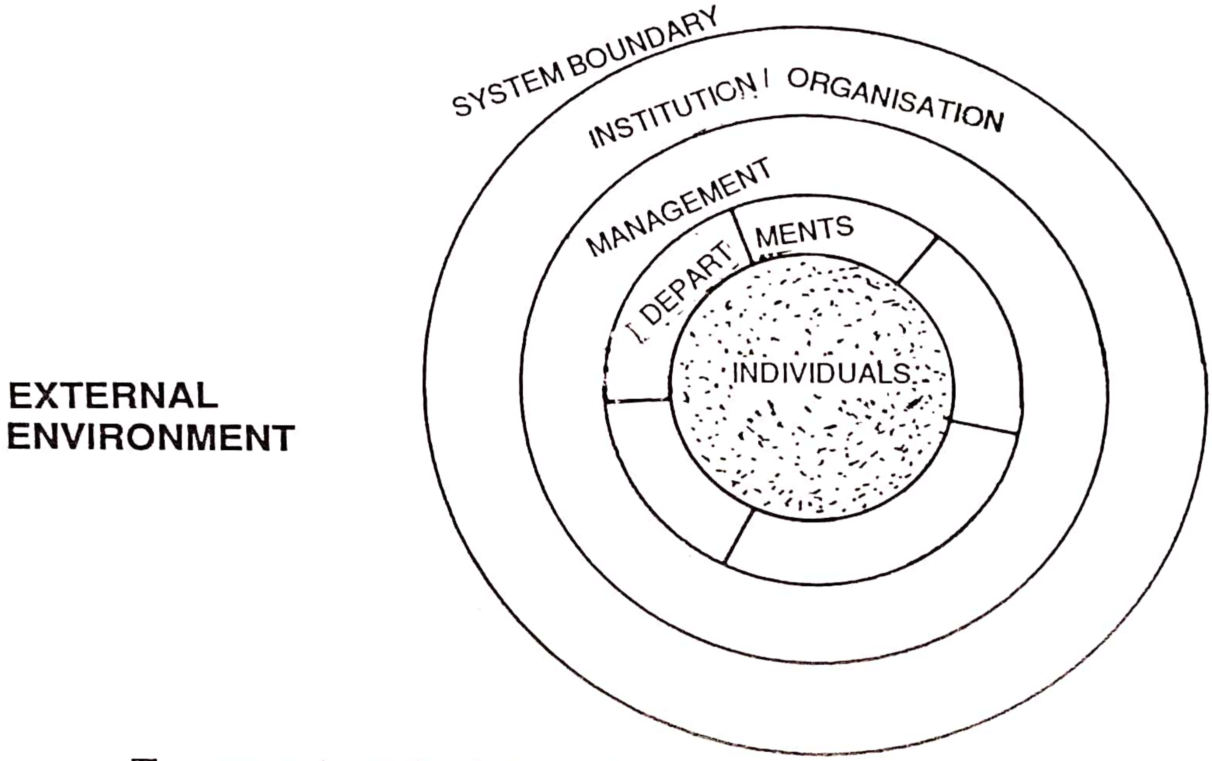
The greatest single barrier to creativity and innovation that I know of is the educational system. I am sure that this is true of most countries. It is sad to recall how inquisitive and curious we all were as small children. Ruggerio[2] in his book on "The Art of Thinking" quotes a researcher who recorded all the questions asked by a 4 year old child over a 4 day period. There were 40 such questions! Even parents grow weary of answering such questions and begin to discourage them with remarks like... "don't ask so many questions". This attitude is reflected in the saying...."little children should be seen and not heard". When the child enters school the situation frequently becomes worse, with too many children and too little time for a teacher to be concerned with individuals. Children are told to be quiet and soon they lose the habit of questioning. Creativity and innovation continue to be stifled by the *one problem, one solution syndrome* that is especially practised in science and technical education. Some years ago, when I was teaching engineering courses at university level in Australia I decided to set examination questions wherein surplus information was supplied - invariably students found some way of using the useless data, often making previously correct solutions wrong. The point is that they had been so conditioned to having the exact amount of information required to solve the problem that almost nobody had the confidence to solve a problem without using all the data given. Of course in the real world of work, engineers have a surfeit of information and a large part of their skills is to select that most appropriate to the problem at hand. Scientific and technical education has been so pre-occupied with "closed end" type problems that their students are often seriously deficient when it comes to tackling "open-ended" problems. Perhaps it is not merely coincidence that the CEO's of many manufacturing enterprises are non-technical people. The management and organisational problems that are confronted on a day to day basis are open-ended, meaning that creativity is an essential element of successful problem solving strategy.

Another manifestation of the one problem, one solution syndrome is the *self-imposed barrier*. How often have we failed to solve problems which require a 3-dimensional approach by using 2-dimensional thinking! As if to further illustrate that we are some kind of prisoners of our own environment, we frequently fail to be creative or innovative by *conforming* to others' expectations. Instead of giving your honest, frank opinions on an issue you tell the boss what you think he wants to hear! This too is a barrier to creativity and is reinforced by another associated barrier, namely the *fear of looking a fool*. Being different is often viewed as risky, especially in bureaucratic organisations, so we take the easy way out and maintain the status quo. You can't make a mistake if you don't do anything is the philosophy of this school of thought. One of the greatest traps technical people (analytical thinkers) seem to fall into is their desire to *evaluate ideas too quickly*. Analytical thinkers usually have highly developed evaluative skills, but unfortunately, to use Edward De Bono's[3] phraseology, they are also predominantly *black hat thinkers*. This means they focus on the logical negative - why the idea will *not* work. One final barrier that is worth - mentioning specifically is the failure to challenge the obvious. We often assume information to be facts and often this is not the case. A better understanding of the difference between terms like data, information, opinion, truth and fact would help in this regard.

I have recently come across an article[4] which suggests 101 ways to enhance creativity in an organisation, so I suppose that by rewording those statements we could come up with a list of 101 ways to kill creativity. However many of them could be classified under the barriers already discussed, but I do recognise that these are by no means exhaustive.

## Suggestions for Skill Development

Highly creative organisations do not happen by accident, rather they are designedly so. Advertising agencies are perhaps good examples. Recognition of this gives us a great insight by first alerting us to the fact that organisations can take steps that will greatly increase the probability of an organisation becoming more creative, even with the same staff. We could visualise three basic levels at which efforts to enhance creativity could be directed. These are the top management level, wherein the major task is to develop a conducive organisational climate; the departmental level where the degree of autonomy would appear to be a critical factor and thirdly at the individual level. This is shown conceptually in next page.




The concentric circles indicate the harmony sought between each level; that is a conductive management will result in greater creativity at the departmental level which reflects increased creativity at an individual level. A second, and equally important point to note, is that the organisation has to be viewed as an "open system" having frequent transactions, taking place across the system boundary in order to be dynamic. Indeed, systematic environmental scanning is a key aspect of strategic thinking.

Perhaps the key to developing a more conductive organisational climate lies in a relaxation of bureaucracy and a corresponding increase in the degree of autonomy that functional units and individuals enjoy. It appears to be a characteristic of creative people that they prefer to work in a climate of greater democracy and freedom, and rules and regulations are often viewed as inhibitors to such creative pursuits. Of course, senior management has to finely balance issues like control, authority, responsibility and accountability against performance.

It is now commonly understood that the skills of creativity and innovation are not entirely genetically inherited characteristics and proper training can greatly enhance these skills. The nature of training required can be inferred from the discussion on barriers. Certainly the development of problem solving skills stands out as a priority area and would go a long way to improving the present situation. At the senior management level these efforts could focus on the themes of strategic thinking and strategic planning since vision and proactivity are essential to the long term health of organisations. Here due emphasis needs to be placed on such techniques as "environmental scanning" which involves a systematic analysis of the present external environment as well as attempts to forecast likely future changes which would impact on the organisation's business. Certainly the creation of a strategic planning unit within an organisation can make a significant contribution to its health and wealth especially so since this becomes a major input to corporate tactical and operational planning.

Experience in industries that produce consumer products have shown that the key to market performance lies in the concept of quality. When we examine public systems of technical education there has in recent years been a major trend towards increased accountability but unfortunately most of this effort has been directed towards quantitative accountability; that is an analysis of the numbers of staff, students, dollars, equipment and building, etc. Relatively less attention has been focussed on qualitative accountability. It is somewhat disappointing to observe that this has produced a sort of mind-set in educational administrators and managers. When they are asked for suggestions on how the system may be improved they come up with predictable lists like provide more staff, equipment, money, and building, etc. Almost nobody is prepared to take the view...given this situation and quantum of resources how can we best utilise them, or, how can we generate additional resources and create a more favourable situation. This requires a creative, innovative approach to thinking. There is a real need to change the mind-set of individuals and specific training on themes such as strategic planning, problem solving and alternative approaches to thinking would help, as would value education. I do not believe there is an acceptable short term solution, but rather it will take time, since such an approach needs to be introduced at all levels of education. After all this mind-set has been produced by a mini-lifetime of conditioning so we might expect the re-conditioning process to also take a mini-lifetime, but progress will be incremental.

Earlier I mentioned the experience in consumer-related industries and their emphasis on quality, which brought about the widespread use of quality circles. This concept is equally applicable to the tertiary education system and could work very well at a departmental level. It should be noted that the major thrust of quality circles is innovation as opposed to creation. Here existing products, processes are analysed with a view to making improvements either in design features, or more usually in production processes, so as to reduce the rate of defects.

Naturally the bottom line to enhancing the creativeness and innovativeness of any organisation is the individuals who make up the work force. Management can do a great deal to influence these individuals. Firstly we must recognise that over any given timeframe the work force is made up of (a) new recruits (b) existing staff. Just as it is possible to measure with some degree of success characteristics and skills such as IQ and aptitude, it is also possible to "measure" creative and innovative talent. Some corporations employ trained professional psychologists when recruiting. Thus we should be able to incorporate creativity and innovativeness into selection criteria. This will go a long way to developing a conducive "corporate culture". To complement this strategy, acknowledged change agents already in the organisation should be recognised and encouraged. If this is done too, then pretty soon the herd instinct will start to convert others in the organisation to a more positive attitude towards creativity, innovation and the inevitable changes that result. Finally an identifiable staff development strategy which puts the development of creativity at the forefront will reinforce the other strategies in place.

A word of caution is perhaps in order at this junction. No organisation wants "creative chaos", rather we need to constantly remind ourselves of the need for harmony of effort. Creative organisations may well require even greater skills of senior managers to ensure that all this creative effort is productive and consistent with the overall goals.

**Thoughts on thinking**

Ruggiero defines thinking thus:

"A purposeful mental activity over which we exercise some control".

The notion of control is crucial to the definition and leads to the view that sub-conscious mind drifting, such as we might experience in dreams, does not constitute thinking. However, this does not mean that unconscious thinking can play no part in purposeful, mental activity; there is ample evidence to suggest that it can! Rather we are distinguishing between active and passive thinking. Breathing and walking are examples of passive thinking, wherein humans are capable of putting themselves into "automatic transmission"[1].

A more formal definition of thinking could be stated thus[2]:

"Thinking is any mental activity that helps to formulate or solve a problem, make a decision, or fulfil a desire to understand. It is searching for answers, a reaching for meaning".

De Bono introduces the ideas of reactive and proactive thinking and suggests that most of us tend to develop only our reactive thinking. It is the proactive thinking that requires creativity and innovation because it is here that we are "making the map, rather than following one".

One of the inhibiting factors that holds back the development of creativity and innovation is often the mistaken belief that these skills are somehow unteachable. As James Mursell notes:

"Any notion that better thinking is intrinsically unlearnable and unteachable is nothing but a lazy fallacy, entertained only by those who have never taken the trouble to consider just how a practical job of thinking is really done."

An appreciation of this last point together with a better understanding about thinking are no doubt significant steps in the right direction. The removal of mystique and confusion will lead to clearer, better thinking skills. This is in essence the message that Edward De Bono gives in his book titled "Six Thinking Hats", and it was written with the express purpose of trying to simplify thinking processes. He avoided theories almost entirely but rather used them in the most practical way. Basically De Bono's point is that most thinking is confused and focusses on an argument style. Much of this masquerades as logical argument, when in reality it is a hotchpotch of emotion and opinion mixed with a sparse dose of facts. He suggests that we should recognise the basic types of thinking, separate them out and carefully record the output of each type of thinking on a "map".

He developed a kind of thinking classification scheme wherein each type of thinking was clearly identified with a thinking hat of a specific colour. This he maintains has a significant added advantage of allowing people to record their previously somewhat difficult to express thoughts, by using the protection of role playing. People can be asked for their "Red Hat" views for instance and they consciously respond by wearing this coloured hat and giving their feelings and emotions on the issue being discussed. Without the protection of the hat, people may be reluctant to express such views or even confuse emotion with objectivity. The objective of the thinking process should be, according to De Bono, to record the key points made under each of these categories on a sort of thinking map. If this is done, then the best route will often become immediately apparent. Confusion is dissipated.

## Concluding Remarks

*"Thinking is the ultimate human resource."* In the past the training emphasis with respect to the development of thinking in technical personnel has been on "black hat" thinking, that is the logical negative type of why something will not work. There is now a greater recognition of the need to actively promote the development of creative and innovative talents in people. Whilst this is undoubtedly a step in the right direction, we need to keep in perspective the need for balanced thinking and a map-making approach to decision-making. Otherwise the pendulum may swing too far and we could end up "throwing out the baby with the bath water". Public systems of technical education are finding themselves increasingly in a competitive business-oriented environment. The fast pace of technological change demands new approaches to curriculum and instructional systems. Failure to respond could spell disaster for technical training institutions and the issue is not whether we need a greater emphasis on the development of creative and innovative skills, but how to go about it.

## REFERENCES

1. KUHN, RL Editor-in-Chief. "Handbook of Creative and Innovative Managers." McGraw Hill, 1988.
2. RUGGIERO, VL. "The Art of Thinking: A Guide to Critical and Creative Thought". Harper and Row, 1984
3. DE BONO, E. "Six Thinking Hats". Pelican, 1985.
4. RANDSEPP, E. "Creative Climate Checklist: 101 Ideas". McGraw Hill 1988.

# The Effectiveness of Computer Simulation in Training Programmers for Computer Numerical Control Machining

YEN-FEI HWANG AND W.D. WOLANSKY

*ABSTRACT*

*The paper reports the findings of a study concerning the effectiveness of microcomputer simulation in learning CNC programming skills. The results revealed that there is no significant difference in achievement among students using a microcomputer with a partner, using a microcomputer alone, and those who did not use a microcomputer simulator. However, the number of questions raised per student in each group during the programming practice period was significantly different. It was also noticed that during the experimental period students in the groups of using computers were more motivated in learning programming skills. It was therefore concluded that computer simulation is as effective as the traditional method. However, the teacher in a CNC laboratory could spend less time with students when they are working on a microcomputer simulator in pairs and as a consequence the teacher can spend more time helping students who are running programs on a CNC machine tool.*

## Background

Numerically controlled machine tools, commonly referred as numerical control machine tools were first developed in 1952 at the Massachusetts Institute of Technology (MIT) laboratories. In 1949, the United States Air Force sponsored research to develop machine tools that could be programmed to produce parts of different sizes and dimensions automatically. This research program was initiated in response to the increasing cost and complexity of aircraft parts. As a result, a numerical control machine tool was developed that could produce a number of different complex parts on the same machine by simply changing a computer program and retooling. The numerical control machine tool also reduced the chances of human error by producing each piece in exactly the same way.

Various other machine tools for turning, milling, planing, sawing, forming, shaping, reaming, boring, and grinding could also be incorporated with the numerical controller.

The more recent advent of Computer Numerical Control (CNC) systems has resulted in more powerful applications of computers in manufacturing.

Due to manpower needs in the manufacturing industry, computer numerical control machine tool operation is expected to be the fastest job-growth area among machine tool operators in the next decade. This growth is needed because of world-wide production competition, continuous advances in machine technology, and the demand for greater precision and higher quality products at a lower cost. The result is a growing use of computer numerical control machine tools.

According to the Bureau of Labor Statistics, among machine tools operators, the demand for numerical control machine tool operators is relatively high. The number of numerical control machine tool operators was expected to rise by about 45% in the 1982 to 1995 period (Nordone, 1985).

To prepare young students for a career within modern industry, it is advisable for educational programs to include both theory and practice of the CNC technology.

Basically, vocational technical education programs should be able to supply the needs of the society and the community. In an industrialized community, schools should be able to supply qualified skilled workers, technicians, or engineers for industry. There is an urgent need for the implementation of numerical control curricula in high schools, community colleges, and universities.

In the past ten years, CNC curricula have spread from the college and university levels to some senior as well as junior high schools. Although there are still many schools that do not have CNC equipment, in the foreseeable future. these schools will be able to access CNC machines. It is obvious that there is a growing awareness of the need for education in the field of CNC technology.

The CNC machine still represents a high-priced equipment item for local schools, event though the price has been gradually decreasing. How to make a CNC machine tool more effective as an instructional device is the responsibility of educators.

The other aspect an educator must take into account is the issue of safety in the use of CNC machine tools, as any mistake or programming error could cause very serious damage to the machine tool or cause personal injury. Verifying the accuracy of the prepared CNC programs before sending them into the CNC machine is of vital importance—one of the important jobs for the CNC lab instructors.

The CNC program simulator is designed specifically for CNC trainees. This is a microcomputer which is used to simulate the CNC program. The simulation package can detect possible mistakes in the program, and can display the tool path on the computer screen. The advantage of the CNC program simulator is that, by checking a CNC program on a microcomputer screen before sending the program to a CNC machine tool, the student and the teacher can be sure that the program is error-free; this prevents mistakes happening on the CNC machine tool.

For most of the local schools or technical training centers, the budget is always limited. It is not likely that a school will have more than one CNC machine of the same type. That means probably not every student has a chance to run a complete program on a CNC machine tool. However, low-priced microcomputer simulators can reduce the time students use on the CNC machine tool. If students write programs and simulate them on simulators instead of on a CNC machine tool, the student will then have more time to share on an available CNC machine tool.

The experimenter was interested in the effectiveness of the CNC machine tool simulators. The question to be answered is: "Is there any achievement difference between a computer-assisted program verification approach and an instructor verification approach?"

Personal computers are now relatively inexpensive pieces of equipment. But, for some schools, it is not economically possible to obtain a sufficient supply of simulation computers. In this case, probably more than one student will be expected to share a computer.

So, the next question to consider was: "Can we identify any significant difference in achievement between the students who work alone and the students who work in groups of two?"

**Purposes of the Study**

The purposes of this study were (1) to investigate the effectiveness of microcomputer simulation and (2) to compare the difference in skill mastery and in the need for a teacher's assistance among the students who work on a microcomputer with a partner, those who work on a microcomputer individually, and those who do not use a microcomputer in learning CNC programming skills.

## Methodology

*Hypotheses of the Study*

1. There is no significant effect of mathematics scores upon the achievement of CNC programming skills.
2. There is no significant effect of drafting scores upon the achievement of CNC programming skills.
3. There is no significant effect of computer concepts class upon the achievement of programming skills.
4. There are no significant achievement differences among the three groups of students who used a computer with a partner, used a computer alone, and the control group which did not have access to computer simulators.
5. There are no significant achievement differences betweens students verifying CNC programs by working at a microcomputer simulator with a partner and those working alone.
6. There are no significant achievement differences between students verifying CNC programs by microcomputer simulators alone and those verifying CNC programs through an instructor.
7. There are no significant achievement differences between students working at a microcomputer with a partner and those verifying CNC programs through an instructor.
8. There are no significant differences in the numbers of questions asked per student, as measured during the practice period, among the three groups of students using a computer with a partner, using a computer alone, and those verifying CNC programs through an instructor.

*Sampling subjects*

The sample consisted of ninety male students enrolled at the National Yunlin Institute of Technology in Taiwan during the 1988-1989 school year. These students were all majoring in the mechanical engineering and the mechanical design Associate Degree programs. Their educational backgrounds were equivalent to twelfth grade students or college freshmen in the United States.

Five classes were selected. Students in each of the five classes were randomly assigned to three groups. For each class, five students were assigned to group one where each student used one computer, six students to group two where every two students shared one computer, and seven students to group three where no computer was provided. A total of eighteen subjects were selected from each class.

*Research design*

A pretest-posttest control group design was used in this study. In order to eliminate possible contamination in the experiment, students were not informed of the experimental plan until the end of the data gathering process. All students in the five selected classes were given a pretest to determine whether they already possessed the information to be learned in the study. Those students who got scores in the pretest were taken out from the sampling process of subjects.

*Simulation package*

A Chinese simulation package was developed by the Multitech Company in Taiwan. The package was built to accommodate personal computers. The major functions of this package included: cataloguing, editing, simulating a CNC lathe program, simulating a CNC mill program, and sending programs to a tape puncher or a CNC machine tool through an RS 232C interface.

*Instrumentation*

Student achievement was measured by two posttest evaluations. The first posttest included fifteen multiple choice items regarding codes and commands used in CNC programming. Both English and Chinese versions were presented in the evaluation. The first posttest was conducted at the end of the second week. The second posttest was constructed of thirty mistake/correction type questions from three CNC programs. Students were asked to pick out mistake commands in the programs and correct them. The second posttest was conducted at the end of the third week. The instrument was evaluated, and revised. The Kuder-Richardson 20 reliability was 0.86.

*Process of the teaching experiment*

The experimental process was completed in three weeks. Each week provided six contact hours of instruction. There were a total of eighteen hours of instruction. The major activities of this study were:

- A pretest
- Classsroom lectures
- .Demonstrations of a CNC machine tool
- .Practice of CNC programming by the three groups
- .Posttest one
- .Posttest two

## Data Analysis and Findings

Based upon pretest scores, the subjects in this study were considered equally knowledgeable of CNC machine programming prior to the study.

A multiple convariance analysis, using General Linear Model Procedures, was used to control error and increase the precision of the analysis. Students' previous experiences in mathematics, mechanical drafting, and computer concepts were used as control variables. Several assumptions have been tested for the valid use of a covariance analysis. These tests included:

1. Testing the null hypotheses that the group variances of three different groups in mathematics, mechanical drafting, and computer concept scores are statistically equal.
2. Testing the null hypotheses that the true group means for mathematics, mechanical drafting, and computer concept scores are equal.
3. Testing the hypotheses that the within groups' regression coefficients are equal.

After these assumptions had been confirmed, the pooled regression coefficients of the control variable were tested. Then the posttest scores of the three groups were adjusted by the covariates, and the adjusted means were compared statistically.

The pooled regression coefficients of mathematics, mechanical drafting, and computer concepts were tested to see if these variable were significantly different from zero.

After running the GLM procedure, it was found that the mathematics and mechanical drafting scores did not have a significant effect on the posttest scores. These two variables were then eliminated from further analysis. The only variable significant at the 0.05 level was the previous scores of computer concepts class.

A covariance analysis, using the computer concepts scores as a control variable, was performed. The results are presented in Table 1. The type III sum square of the groups is 22.69 and the PR value is 0.788. It can be concluded that there is no significant difference in achievement among the three groups of students which used computers with a partner, used computers alone, or did not use computers at all.

The group means of posttest scores were adjusted for the computer concepts scores. The adjusted means of the three groups were then compared to each other and are reported in Table 2. The results

Table 1. Type III sum squares of the covariance analysis using computer concept scores as a covariate

| Source | DF | Type III SS | Mean Square | F value | PR > F |
|---|---|---|---|---|---|
| GRP | 2 | 22.69 | 11.35 | 0.24 | 0.7880 |
| Computer | 1 | 430.32 | 430.32 | 9.06 | 0.0034 |

Table 2. The t-test of the least square means of group 1, group 2 and group 3

| PROB > \|t\| | Ho: | LSMEAN (i) | = LSMEAN (j) |
|---|---|---|---|
| i/j | 1 | 2 | 3 |
| 1 | | 0.8382 | 0.5107 |
| 2 | 0.8382 | . | 0.6375 |
| 3 | 0.5107 | 0.6375 | |

Table 3. The analysis of variance performed on the means for students' questioning rate

| Dependent Variable: AVEQUES | | | | | |
|---|---|---|---|---|---|
| Source | DF | Sum of Square | Mean Square | F | PR > F |
| Model | 2 | 5.188 | 2.594 | 11.49 | 0.0016 |
| Error | 12 | 2.710 | 0.226 | | |
| Total | 14 | 7.898 | | | |

Table 4. The Tukey studentized range test for variable AVEQUES.

Tukey's student range test for variable of AVEQUES

ALPHA = 0.05 DF=12 MSE=0.225839

Critical value of studentized range = 3.773

Minimum significant difference = 0.80186

| TUKEY GROUPING | MEAN | N | GRP |
|---|---|---|---|
| A | 2.9200 | 5 | 1 |
| B | 1.8000 | 5 | 2 |
| B | 1.5754 | 5 | 3 |

Means with the same letter are not significantly different.

demonstrate that no significant difference in achievement at the 0.05 level was found between any two of the three groups.

The number of questions raised by students during the practice period of programming were recorded. A comparative study was done to evaluate any differences in the number of questions posed by each group.

The results of the analysis of variance (ANOVA) in Table 3 show significant differences at the 0.05 level. The Tukey method was used to examine the pairwise comparisons. Table 4 shows that the students verifying CNC programs by working at a microcomputer simulator alone had significantly more questions than those working at a microcomputer simulator in teams and those verifying CNC programs through an instructor. The students verifying CNC programs by working at a microcomputer alone did not significantly differ in the number of questions per subject from those verifying CNC programs through an instructor.

## Conclusions

### *Conclusions of hypotheses 1 through 3*

The possible effect of previous experience in computer concepts, mathematics, and mechanical drafting classes upon mastery of CNC programming skills is studied. Only background in computer concepts significantly affects student performance in the CNC programming class, while background in mathematics and mechanical drafting does not.

*Conclusions of hypotheses 4 through 7*

Based upon the findings presented in Tables 1, and 2, these three different approaches are equally effective for students attempting to obtain knowledge and skills of computer numerical control machine programming. There are no significant differences in achievement regarding the CNC programming skills among the students in the three different treatment groups.

*Conclusions of hypothesis 8*

Based upon the findings presented in Tables 3 and 4, the numbers of questions raised per student in each group are significantly different for the three different teaching approaches. Group one students, those who used program simulation packages individually, have significantly more questions per student than those who used program simulation packages with a partner and those who did not use a microcomputer program simulator at all.

Students who did not use a micro computer program simulator were allowed to discuss the CNC programs with their classmates during the class session. The students who used a program simulation package with a partner were also allowed to discuss the programs with their teammate. However, the students in group one, who used the microcomputer alone, did not have a partner with whom to discuss their findings. This is considered the main reason for the differences in student performance.

**Discussion**

Results reveal that course grade in a computer concepts class significantly affected students' performance in a subsequent CNC programming class. However, computer anxiety may be a confounding factor in these results. Computer anxiety usually appears in the form of a negative attitude toward computer technology. The negative attitude includes resistance to talking or even thinking about computers (Chuang, 1988). Many studies have been conducted in the field of computer anxiety. A conclusion was drawn by Cambre and Cook (1985) that there were relationships between exposure to computer terminal use and changes in basic physiological activity regardless of prior computer exposure. Moreover, a significant decrease was found in anxiety as a function of utilization of the computer terminal.

The computer concepts class had a significant effect on students' performance in CNC programming classes. Perhaps those students who had higher scores in the computer concepts class and got higher scores in CNC programming might have a lower level of computer anxiety.

This study found that three different approaches are equally effective for students attempting to obtain knowledge and skills of computer numerical control machine programming. However, it was noticed that during the experimental period students in the groups using computers were more motivated in learning CNC programming skills. Students in the group which did not use computers appeared more passive in the learning activity.

The results of this study also implied that the lack of sufficient expensive CNC machine tools should not reduce the opportunity for students to learn CNC programming and operations. Since microcomputers are very popular in technical institutes and colleges in Taiwan, computer simulation on a microcomputer is a very feasible way of teaching CNC programming.

Since computer simulation is as effective as the traditional method, if computer simulation was used properly, the instructor could spend more time monitoring CNC machine tool operations as opposed to assisting students in programming. The results concerning the number of questions raised per student in the CNC programming class showed that a group of two students, who shared a computer had significantly fewer questions per student than those students who used a microcomputer alone. The results support the conclusion that the teacher in a CNC laboratory could spend less time on students when they are working on a computer in pairs. The teacher then could spend more time helping students who are running programs on a CNC machine tool.

The results regarding the optimum group size of teams is consistent with previous suggestions by Larsen (1979) and the previous findings of Trowbridge and Durnin (1984).

**Recommendations**

Based upon the results of this study, the following recommendations are made:

*For CNC instructors*

1. Inexpensive microcomputer simulation package is equally effective and does not have negative effect upon students' learning of CNC programming skills. On the other hand, microcomputer simulation package can help teachers to diagnose and discover possible defects in CNC programs before they are run on a CNC machine tool.
2. A group of two students can better use a microcomputer simulation package; these students need less assistance from an instructor. This arrangement does not have any negative effect upon student achievement, but gives students a chance to discuss findings with their classmates. It is obvious that peer discussions are very helpful in the study of CNC programming skills.
3. Background in computer concepts does provide a slight advantage when learning CNC programming skills. It is thus suggested that computer concepts should be taught in advance of the CNC programming class.

*For further research*

1. Replication of this research at other institutions to measure the possible effects of computer simulation in teaching CNC programming skills is recommended.
2. Other simulation packages are recommended for further similar research, to detect possible differences in students' learning outcomes in different simulation packages.
3. Further studies using additional variables, such as computer anxiety, interest, and aptitude, are also recommended.
4. A study should also be conducted to determine whether more exposure to a computer simulator-aided CNC programming class will make any significant difference in student achievement among experimental and control groups. Perhaps doubling the time to 36 hours of instruction could be tested for its potential affects on achievement.

## REFERENCES

CAMBRE, M.A. & COOK, D.L. (1985). Computer anxiety: Definition, measurement, and correlates. *Journal of Educational Computing Research, 1* (1), 37-54.

CHAMBERS, J.A., & BORK, A. (1980). Computer assisted learning in U.S. Secondary/elementary Schools. The Association for Computer Machinery, New York, N.Y. Eric Ed 202 461.

CHUANG, Y.R. (1988). *An examination of the correlation between computer anxiety and tool anxiety.* Doctoral dissertation, Iowa State University.

COX, D.A. & BERGER, C.F. (1985). The importance of group size in the use of problem-solving skills on a microcomputer. *Journal of Educational Computing Research, 1 (4), 459-467.*

JOHNSON, D.W., JOHNSON, R.T. & STANNE, M.B. (1985). Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction. *Journal of Educational Psychology, 77* (6), 668-677.

KLINKEFUS, M.A. (1988). *Paired versus individual learning when using computer-assisted instruction.* Unpublished master thesis, Iowa State University, Ames, Iowa.

LARSEN, S.G. (1979, Sep.). Kids and computers: The future is today. *Creative Computing, 5* (9), 58-61.

NORDONE, T. (1985, Spring). Numerical-control machine-tool operators. *Occupational Outlook Quarterly, 29* (1), 10-14.

Numerically controlled machine tool operators. (1986, October). *Industrial Education, 75* (7), 9-10.

OKEY, J.R. & MAJER, K. (1976). Individual and small-group learning with computer-assisted instruction. *AV Communication Review, 24* (1), 79-86.

PINE, D.T. (1973). *The effects of teaching numerical control concepts via simulator versus non-simulator activities on the achievement, programming proficiency, and attitude of high school students* (Doctoral dissertation, Ohio State University). Dissertation Abstracts International, 34, 4819A-4820A. (University Microfilms No. 74-3290)

RAPELLO, R.G. (1986). *Essentials of numerical control.* Englewood Cliffs, New Jersey: Prentice-Hall.

ROBLYER, M.D., (1985). *Measuring the impact of computers in instruction.* Washington, D.C.: Association for Educational Data Systems.

The way ahead for computer in manufacturing. (1980, April). *The Production Engineer, 74* (7), 27-29.

Training workers for CNC machining. (1985). *Industrial Education, 74* (1), 15-16.

TROWBRIDGE, D. & DURNIN, R. (1984). *Results from an investigation of groups working at the computer.* California University, Irvine, CA. ERIC ED 238 724.

# Deference to Sex: Perceptual Differences between Male and Female Technician Teachers

TERRY LANE

*ABSTRACT*

*Sex bias is often suggested as one reason for the low participation of women (either teachers or students) in Technician Education. Some elements of women's participation were examined in a study conducted by members of the Colombo Plan Staff College in 1989, among them aspects of sex bias in the curriculum. In this study data from the original research is examined more closely, specifically to determine the nature of sex 'bias' among male and female technician teachers. The analysis indicates that differences in perception between male and female teachers can be attributable to the differences between sex 'bias', on the one hand, and sex 'deference' on the other. The writer suggests that low participation of women in technical education has more to do with female 'deference' than with male 'bias'.*

## Introduction

Last year members of the Colombo Plan Staff College completed a study concerned with the status, role and opportunities of women in national development, particularly in the context of developing countries in the Asia-Pacific region. The study sought to identify relationships between teacher and student attitudes in the context of technical and vocational education (TVE).

In that study, involving as it did data from nine countries of the region, it was found that the perceptions and attitudes of teachers in technician education differed between certain country groups. The researchers concluded:

> The findings leave no doubt that membership of a country is a significant correlate of teacher and student attitudes... Despite the similarities of teachers, and the general similarities of the teaching environments, these characteristics are of less significance across country boundaries[2]

The researchers continued:

> However, that is not to say that the environment of technical and vocational education is not important. In fact, the contrary is implied. Thus, within each country, the environment takes on its important role in shaping attitudes.
>
> The qualification is only that such environments are defined by the characteristics of the country: not by the characteristics of groups of countries.[3]

As a significant variable, though, "country" was not closely defined in that study. Indeed, the variable was included in the research design merely to code membership groups and the researchers had not sought closer definition of "country".

Yet it was clear that there was a need for further explanation, and some indicators were noted:

> ...because of the way in which we have defined some of ..[the]..variables we can judge how country of origin plays such a large part. Religion, for example, follows a regional pattern and country is identified by its religion. Attitudes to work, to women, to careers and to teaching...are also part of a country's social and moral fabric. That fabric does not stretch beyond the bounds of the countries participating in this study, as was anticipated. Nor should it be required to. But this means that policy in technical and vocational education cannot be successfully implemented across national boundaries unless some account is made of these differences.[4]

*The Present Study*

The present study is an extension of that original research and my purpose is to provide an explanation for the relationships found between Country, Religion and Sex and the perception of male and female teachers in Technician Education. More specifically, data from the original study are used to illustrate a particular theoretical perspective and a particular methodology which, together, contribute to and shape our understanding of the nature and the structure of teacher perceptions.

The underlying theme of the original study was that of sex bias in technical and vocational education, and of the outcomes some were directed to strategies which might be employed to minimise sex bias in the curriculum, and in the TVE environment. That theme is taken up here as well, though my emphasis is to add to our understanding of the nature of 'sex bias' rather than to propose strategies to reduce it. The motive to do this comes from the necessity to unravel the correlations between country, religion and sex of TVE teachers.

*Theory and Measurement*

An additional motive for this study is found in the ways we seek to understand and to measure 'perceptions'. Our initial tendency is to attribute individual perceptions to objects, events or conditions identified in the environment. Further, we make the reasonable assumption that perceptions *of or about* something in that environment inform us about that 'something'. Yet this need not be so, and I will suggest that our perceptions inform us about ourselves by revealing the ways in which we tend to perceive the outside world.

But to reveal perceptions in this way requires that we measure them in particular ways. In the original study this was done. Indeed in that study perceptions of technician teachers were obtained in a variety of ways. For the present purposes, the examination of teacher perceptions relies on one specific approach to measurement and on the associated interpretation of data.

This study constitutes an exploration and an illustration of theory and measurement of individual perceptions. It is both an extension of and a clarification of the original research, and it has as its focus the understanding of sex bias among male and female teachers in technical and vocational education.

## Nature of Perceptions

The role of women in education[5] and in organisations[6] arises as a social issue whenever opportunities for a nation are perceived to be more favourable through an increase in workforce numbers[7]. Yet national policies which might increase the number of women in the workforce and which might, thereby, increase opportunities for nations to develop are not readily achieved.

The reasons for resistance to change which alters both the place and the status of women in a society are well known: social, cultural and political factors are both legion and pervasive. Yet the specific impact of such factors is less well known, and the translation of moral, ethical and religious mores into everyday action is not easily traced. These poor linkages give motive to efforts to assess and to act on behalf of women, to redress the balance between social and occupational roles of males and females and to delineate policy options to ensure desired changes.

The desire to change women's roles is not local: both Western and Eastern countries share the view. The focus of change is more specific, however, for no matter at what level discussion of the issue takes place[8,9] the purpose of policy is to provide women access to education and free access to the world of work.

Much of that work, particularly in developing nations, is of a technical nature where the manpower requirement is for technicians - for those who can provide for industrial growth and development. But for women, in the industrial sector, opportunities are not as readily available as they are for males[10] and for girls, in the technical education sector, the opportunities for learning and the educational environment are not always conducive to their acceptance[11,12]

### *The Role of Sex Bias*

Affirmative action for women and girls, not only in technician education, results from the perceived bias toward the female sex by males. That bias, as has been shown, gives rise to legal, social and individual inequalities which women need confront[13]. Patriarchy, even if its institution and history has not been deliberately contrived to repress the female of the species, produces just that result.

If it is alleged that men are biased against womens' participation in work it is on the presumption that men regard females as less capable or less suitable than men. For certain occupations this "bias" may represent, in fact, a non-biased assessment of capability. There is no question, for example, that an occupation involving heavy labour may be more effectively taken up by males. But there is no question either that, for many occupations-even those which call for much physical exertion-women are as capable as men.

### *Male & Femal Bias*

Bias is the perception of difference where, using some objective criteria, none is found to exist. Yet bias is asexual: women along with men can take on and hold views which are biased towards women's participation in work. In this, I think, there is no controversy.

Controversy may obtain, however, as to whether males display more bias toward women than women display toward their own sex. In other words,as has been suggested elsewhere[14], some of the barriers which women need overcome in seeking equality may be those which they have themselves erected.

### *Sex Bias and Sex Deference*

Sex bias can be expressed as a perception of the opposite sex as being different from one's own, where the difference is unable to be substantiated. In an ideal world, on the issue of suitability to certain occupations, sex bias ought not be found in the perceptions of either males or females.

In a general sense of the word "bias" can be both positive and negative, as one may be biased either "in favour of" or "against". Yet in the phrase "sex bias" the word bias is taken to imply that the opposite sex is perceived negatively: that is, to possess less - rather than more - of a particular quality or characteristic. Accordingly, and so as not to confuse, the word "bias" will be used with the negative connotation. To indicate the opposite, to indicate a perception which is more favourable to the opposite sex, the term "deference" is used.

### *Object of the Present Study*

In the original study of teacher attitudes it was argued that the environment for female technician education students would be influenced by the perceptions of the male and female teachers in the institutes. Specifically, the environment would be a more difficult place for female students, should there be a bias against them (and thus in favour of male students) evidenced in the perceptions of either (or both) male and female teachers. Though the findings were reported, it was not investigated whether the found differences were due to sex bias or to sex deference, nor on the specific nature of the difference in perceptions. To do these things is the object of the present study.

## Methodology

Data from the original study were used for the present purpose. Data comprised 245 male and female technician teachers from nine countries, with data categories as shows below. Not all categories are used in the present study, however, as is explained shortly.

- *Country of Origin:* Bangladesh, India (West Bengal), Sri Lanka, Malaysia, Philippines, Thailand, Indonesia, Singapore, Fiji.
- *Religious Affiliation:* Buddhist, Christian, Hindu, Muslim, Other.
- *Sex*
- *Scores on two scales:* Characteristics of Male Students (Boys), Characteristics of Female Students (Girls)

### *Data Collection*

Data were collected between April and June, 1989, following formal approaches through the Liaison Officers of the Colombo Plan Staff College in each country. These were obtained from male and female teachers in technical and vocational institutions in capital cities. In seem cases the researcher administered the survey instrument whilst in the country. In other countries the instrument was administered by a local official.

### *Study Variables*

**Categories** Country of Origin, Religious Affiliation and Sex were variables recorded as part of the respondents' biographical record. Each was scored, for the purpose of analysis, in the same way.

Membership in a particular group is recorded as '1', non-membership is recorded as 'O'. Accordingly, for each separate category (each country, each religious group and each sex) there are recorded two groups: those that belong to the category, and those that do not.

**Scales** Two scales were employed, one to record responses to the Characteristics of Female Students (Girls) and one to record the Characteristics of Male Students (Boys). (See Appendix A) The scales were based on procedures related to the Semantic Differential[15] and used a seven point scale for nine bi-polar adjectival pairs. Teachers were asked to rate 'Male Students (Boys) in my Institute' and, separately, 'Female Students (Girls) in my Institute'.

| | | |
|---|---|---|
| Pleasant | – | Unpleasant |
| Intelligent | – | Stupid |
| Bad | – | Good |
| Passive | – | Active |
| Strong | – | Weak |
| Fast | – | Slow |
| Tense | – | Relaxed |
| Honest | – | Dishonest |
| Ugly | – | Beautiful |

The scale for Male Students (Boys) was presented with the words in the order and placement (left or right) as above. The scale for Girls reflected a different order and placement. During scoring, however, the two scales were matched: responses were ordered according to the sequence in the Boys scale and reversed, where necessary, so that a score of '7' represented the positive word of the word-pair.

In the present study, so as not to confuse Male and Female teachers with Male and Female students, the teachers are referred to as "Male" and "Female" whilst the students are referred to as "boys" and "girls".

*Procedural Steps*

**Screening** Teachers were categorised according to membership of Country of Origin, Religious group and Sex. The initial step in the analysis was to screen out those categories not significantly related to the criterion. The procedure for screening was to calculate on overall difference score for teachers. Items on each of the Boys and Girls scales were summed to give a scale score, and then score for Boys was subtracted from the score for Girls.

For the respondent group of 245 the resultant Difference Score had a Mean value of 0.08 and a Standard Deviation of 6.3. The Minimum score was -15; the Maximum +25.

The Country, Religion and Sex variables were correlated with the Difference Score to effect initial screening. Correlation coefficients, levels of significance and respondent numbers are shown in next page.

Finally, those countries in which the numbers of Male and Female teachers (Bangladesh, Indonesia & Thailand) were disproportionately represented were excluded.

The screening procedures resulted in the following groups being included for the study comparisons: Malaysia & Philippines; Christian and Muslim, and Sex. Respondent numbers vary for each group.

## Results

Results are presented for the Total Sample, for Males and Females separately, for Countries and for Religions. Thereafter are presented comparisons of Male and

Female Teacher responses for each of the country and religious groups.

Results are presented in this sequence to provide ease of interpretation. It will become clear that each successive sequence of graphs provides greater definition of the differences between groups, but particularly the differences between Male and Female Teachers.

*Total Sample*

Graphs for the Total Sample provide profiles for base comparisons. Though they are not intended to represent norms of any kind in this study, we start with them. The first set of graphs will be used to explain the form of the graphic presentation as well as the nature of the scores for each group of respondents.

**All Teachers** Figure 1 shows the graph for the Total Sample of Teachers from Technical and Vocational Institutions.

The graph shows the difference between the ratings for Girls and the rating for Boys, for each of the nine characteristics. As was explained, the Difference Score is obtained by subtracting the mean rating for Boys from the mean rating for Girls. This score is then expressed as a proportion of the *lower* mean score.

The total sample graph represents, within the limitations of the sample, an approximation of a 'normal' profile. Thus it can be seen that, in general, Girls (Female Students) are rated higher than Boys (Male Students) on the characteristics:

| | |
|---|---|
| Beautiful | (Ugly) |
| Honest | (Dishonest) |
| Good | (Bad), & |
| Pleasant | (Unpleasant) |

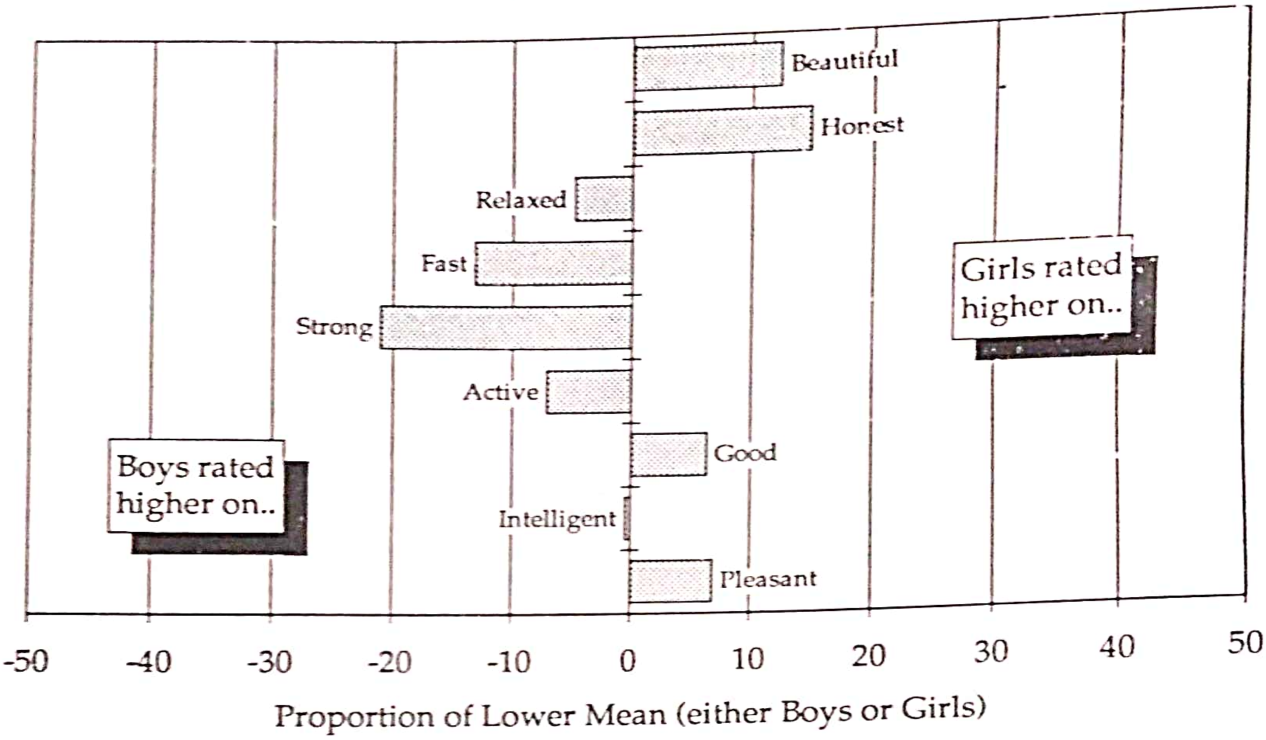
Alternatively, Boys are rated higher than Girls on:

| | |
|---|---|
| Relaxed | (Tense) |
| Fast | (Slow) |
| Strong | (Weak) |
| Active | (Passive), & marginally more on |
| Intelligent | (Stupid) |

These ratings agree, intuitively, with our broad assessment of the characteristics

| **Country** | **Male** | **Female** | ***r*** | **sign. level.** |
|---|---|---|---|---|
| Bangladesh | 20 | 3 | .13 | < .05 |
| *Fiji* | | | *.06* | |
| *India (WB)* | | | *.04* | |
| Indonesia | 9 | 4 | -.14 | < .05 |
| Malaysia | 35 | 42 | -.21 | < .05 |
| Philippines | 15 | 17 | .15 | < .05 |
| *Singapore* | | | *-.05* | |
| *Sri Lanka* | | | *-.02* | |
| Thailand | 1 | 17 | .11 | < .05 |
| **Religion** | | | | |
| Muslim | 49 | 39 | -.12 | < .05 |
| Christian | 22 | 33 | .11 | < .05 |
| **Sex** | 134 | 111 | .03 | < .05 |

*Figure 1 Sex Bias/Deference*
*Total of Male & FemaleTeachers*




of sex: of males and females. Note, as well, the consistency between characteristics which are descriptive of appearance (Beautiful) and intrinsic (Good, Honest) or social (Pleasant) qualities and those which are descriptive of action (Fast, Strong, Active). In general, all respondents will group characteristics in these ways.

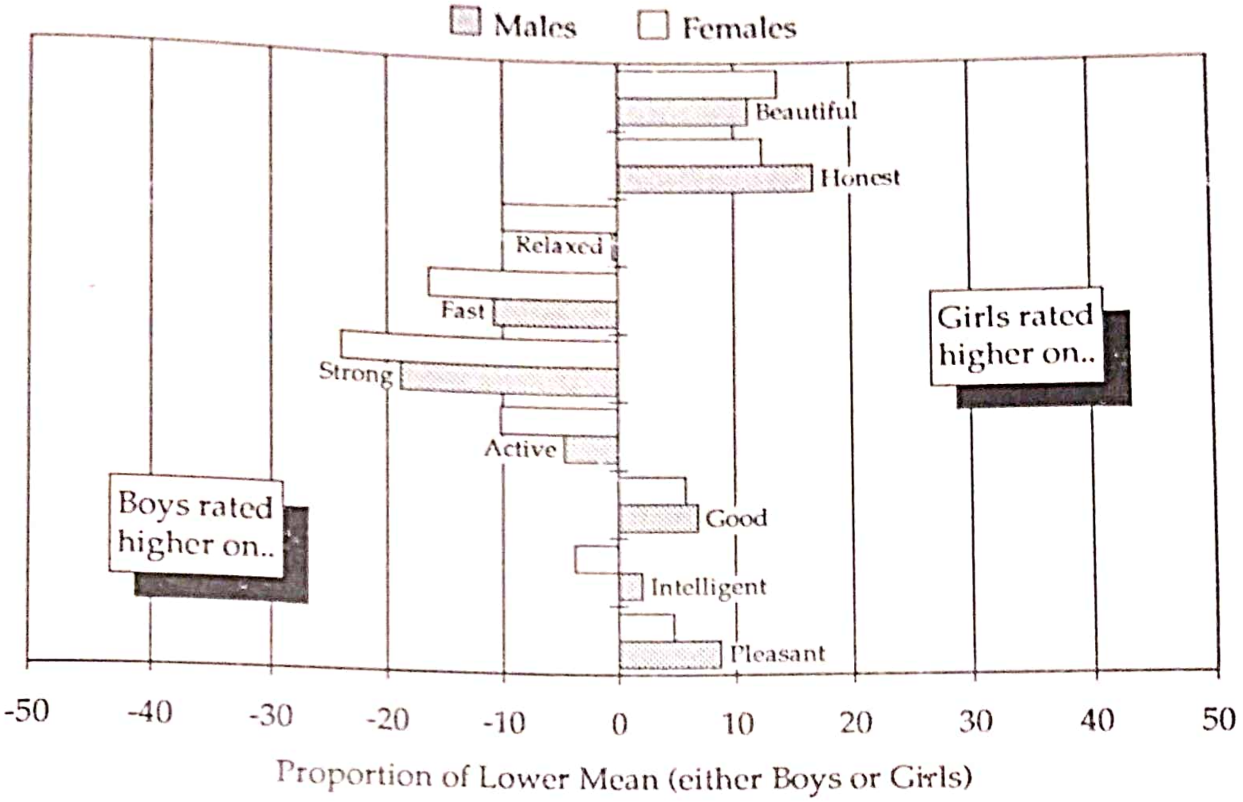
Finally, the two characteristics of Active(Passive)and Intelligent(Stupid) will change from group to group and represent a special interest. It is of some note that, in the Total Sample, there is very little difference perceived between Boys and Girls on the characteristic Intelligent (Stupid). Again, our intuitive judgement is that this perception is correct. But, depending on country, religion and sex, that perception changes.

**Male & Female Teachers** Figure 2 shows the graphs for all Male Teachers and all Female Teachers.

Sex Bias and Sex Deference are represented on these graphs since the grouping is by sex. Accordingly, for Male Teachers Sex Bias is shown on the left hand side (Boys rated higher on..) and Sex Deference is shown on the right hand side (Girls rated higher on..). For Female Teachers Sex Bias is shown *on the right* and Sex Deference is shown *on the left*.

The graphs are comparable in two respects. First, they illustrate how Males and Females perceive their own and their opposite sex, and this comparison reveals the differences in perceptions. Second, they illustrate the *strength* of the Bias or Deference: the extent to which either Male

*Figure 2 Sex Bias/Deference: Total Teachers*




or Female Teachers show bias or deference. These two aspects are revealed for each of the paired comparisons presented, as may be seen from Figure 2.

On this graph both Male and Female Teachers rate Girls higher on the descriptive characteristics: Girls are Beautiful, Honest, Good and Pleasant. Females display Bias on the characteristic Beautiful, whilst Males display Deference on the characteristic Honest. Further, both Males and Females rate Boys higher on the characteristics Relaxed, Fast, Strong and Active but, as can be seen, Female Deference is much stronger on these characteristics than Male Bias.

Importantly, Females defer to the opposite sex on the characteristics Relaxed and Intelligent. Though Males Defer on Intelligent as well, they are less generous when it comes to Relaxed.

The feature of this comparison is the strength with which Females defer to the opposite sex on those characteristics which seem, on the surface, to be important in the world of work: Intelligence, Activity, Strength, and being Fast and Relaxed. It would be wrong to draw too many conclusions from this comparison alone, however, and I turn to the others.

### *The Countries: Malaysia & Philippines*

Malaysia and the Philippines represent the greatest contrast between the nine countries in the original study, but their differences are confounded by religion. If this is kept in mind, though, this comparison is useful.

*Figure 3 Sex Bias/Deference: By Country*

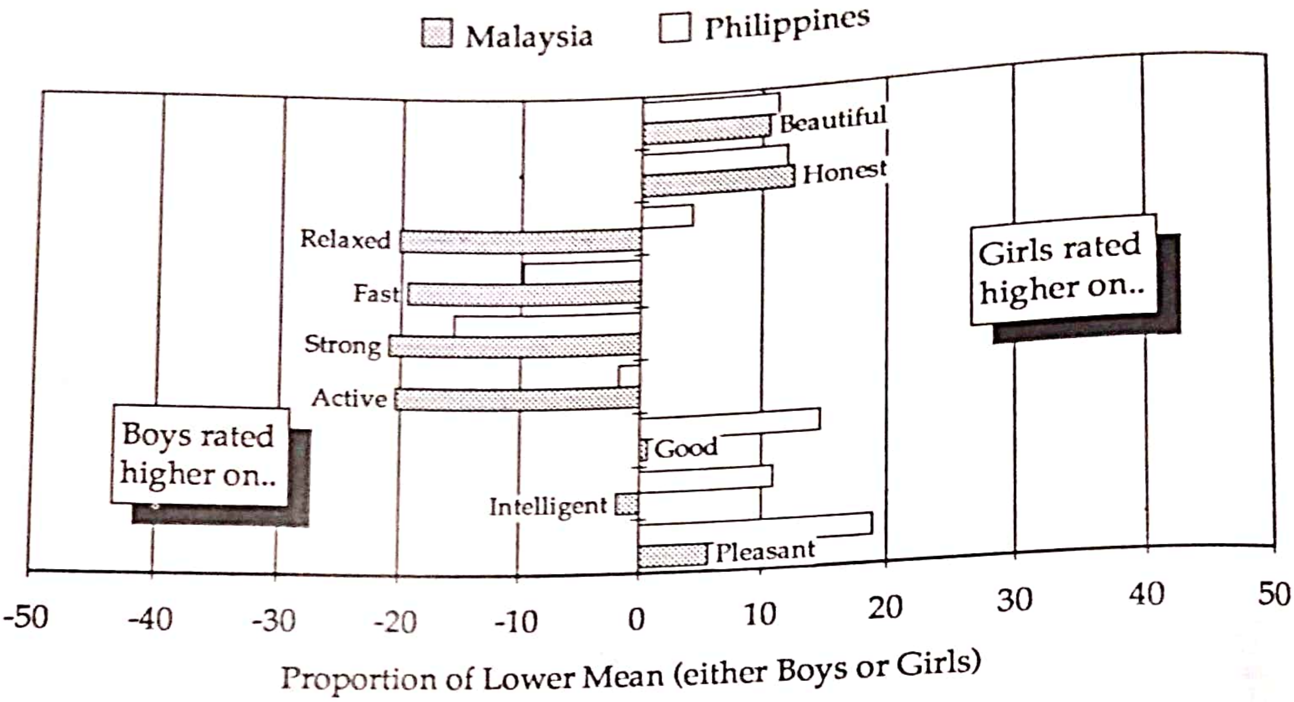



Figure 3 illustrates the country profiles for Malaysia and the Philippines. Comparison of the two profiles is both interesting and informative.

Most striking is the contrast between the strengths of the ratings for Boys (Malaysia) and Girls · (Philippines). Although in both countries Girls are seen as Beautiful, Honest and Pleasant, in the Philippines the strength of this perception is marked. Further, and in the Philippines, Girls are rated higher than Boys on Intelligent and Relaxed, in contrast to Malaysia, and higher on Pleasant than in Malaysia.

The ratings for Boys are equally contrasted. In Malaysia Boys are rated higher than Girls on Relaxed, Fast, Strong and Active, and about equally so. In the Philippines the perception of Boys is biased but more aligned with the physical capabilities of the sexes: Boys are regarded as Strong and Fast and slightly more Active.

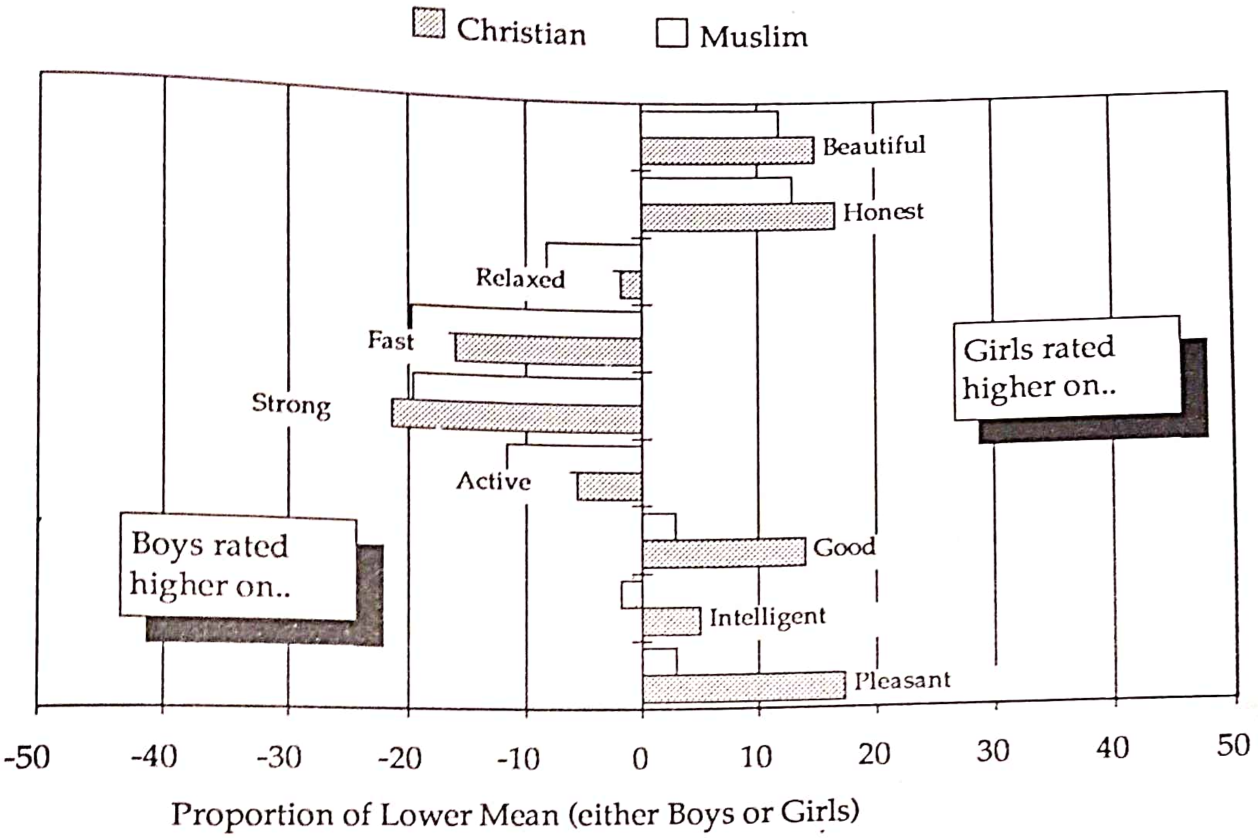
*The Religions: Christian & Muslim*

Figure 4 shows the graphs for respondents grouped according to Christian and Muslim religious affiliation. The contrasts are present, though not as marked as the country comparisons above.

Christian Teachers rate Girls higher on Beautiful, Honest, Good, Intelligent and Pleasant. Muslim Teachers, as well, rate Girls higher than Boys on these characteristics, with the exception of Intelligent, though not to the same extent. In other words the strength of Bias and Deference is weaker.

The marked differences relate to Relaxed, Active and Intelligent.

*Figure 4 Sex Bias/Deference: By Religion*




*Sex: By Country & by Religion*

Results are presented, now, for each country and religious group separated into Male and Female. For these comparisons the role of Sex Bias and Sex Deference will be clear from the paired graphs. In each case, without regard to the sex of the Teacher, graphs are drawn for the difference between the rating of Girls and the rating of Boys.

**Malaysia** Figure 5 shows the graphs for Malaysian Male and Malaysian Female Teachers.

Both Male and Female Teachers display Bias and Deference which is generally consistent with the Total Sample. However there are marked deviations. Most noticeable is the strength of Female Deference, and particularly on Relaxed, Active and Intelligent. It is of some note, as well, that Female defer to the opposite sex on the characteristic Pleasant.

**Philippines** Figure 6 shows the graphs for Philippine Male and Female Teachers.

Comparison of the graphs is favourable for Girls, regardless of the sex of the Teacher. However Females Defer to Boys on Fast and Strong much more so than do Male Teacher exhibit a Bias on these characteristics. Both Male and Females, interestingly, rate Girls higher than Boys on Intelligent, but Males much more so than Females.

**Christian** Figure 7 shows the graphs for Christian Male and Female Teachers.

*Figure 5 Sex Bias/Deference: Malaysia*

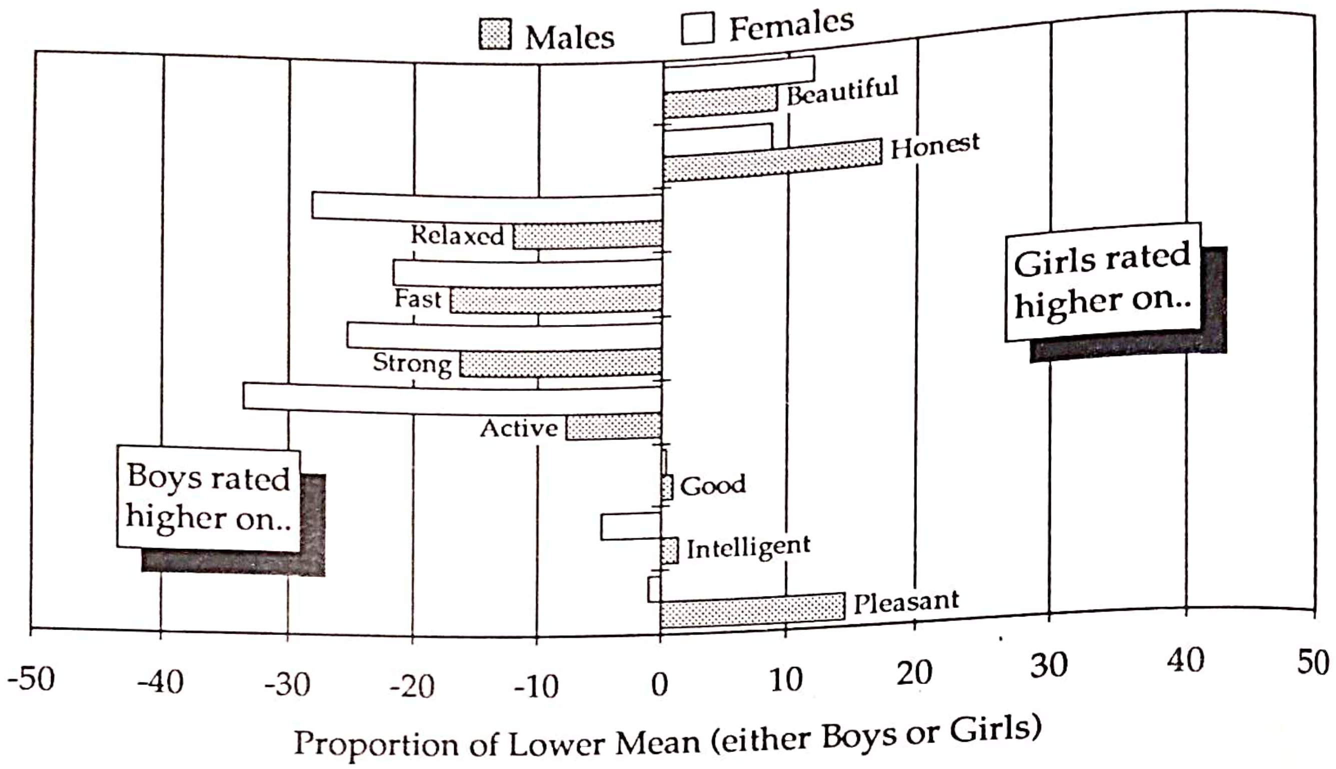



*Figure 6 Sex Bias/Deference: Philippines*

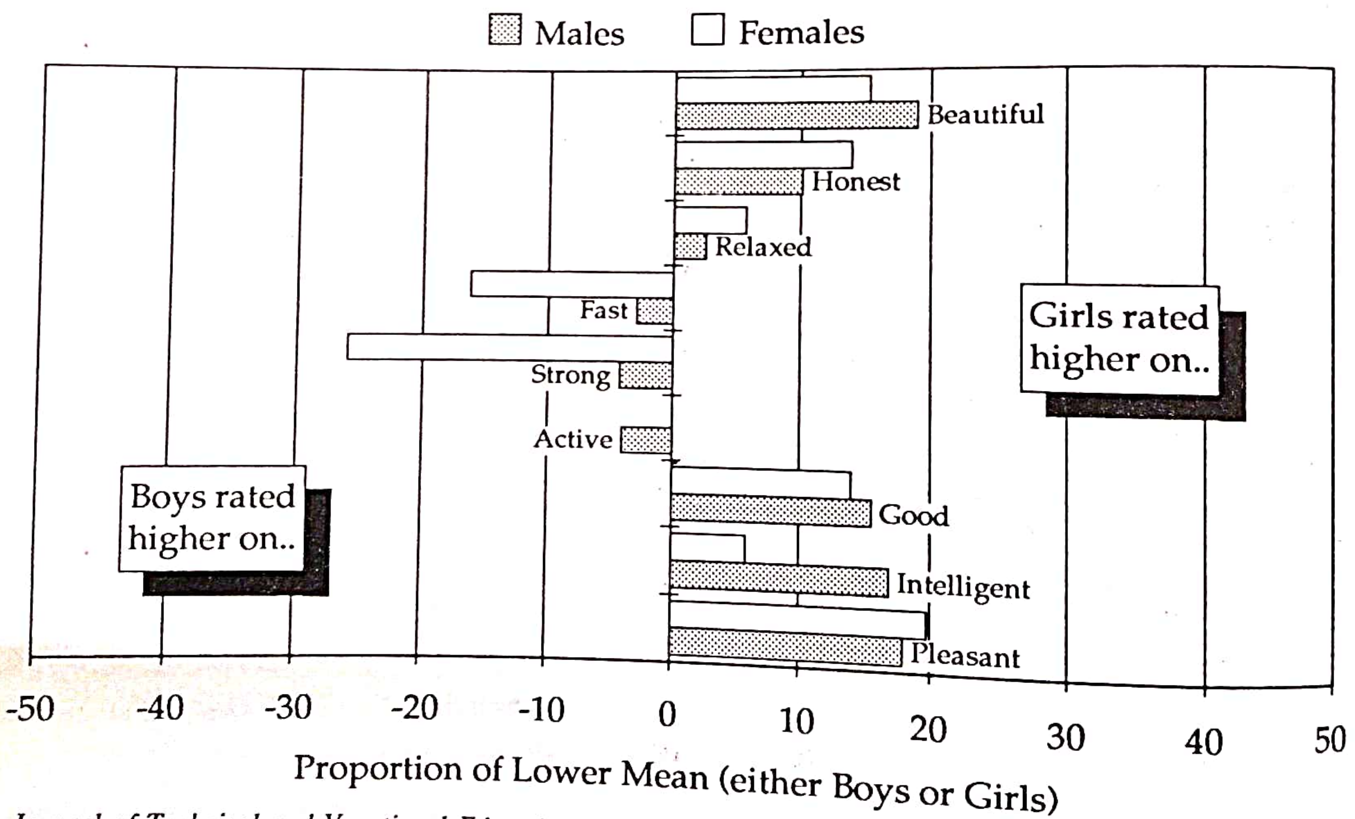


*Figure 7 Sex Bias/Deference: Christians*

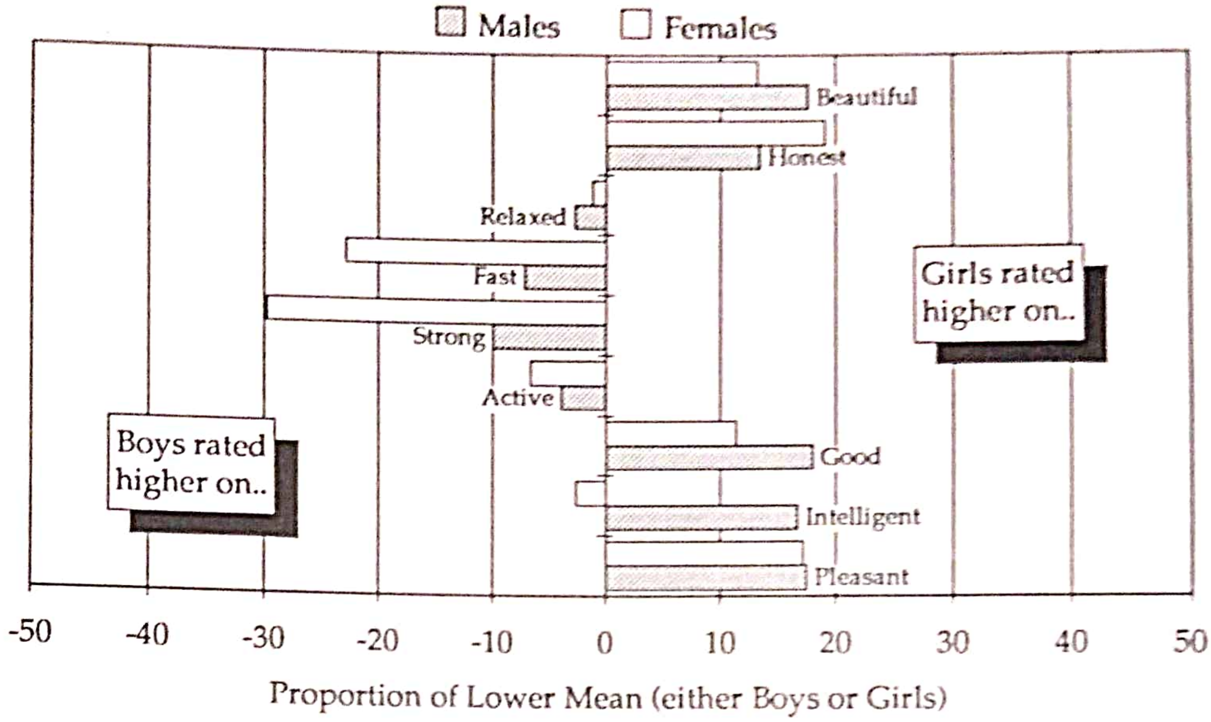
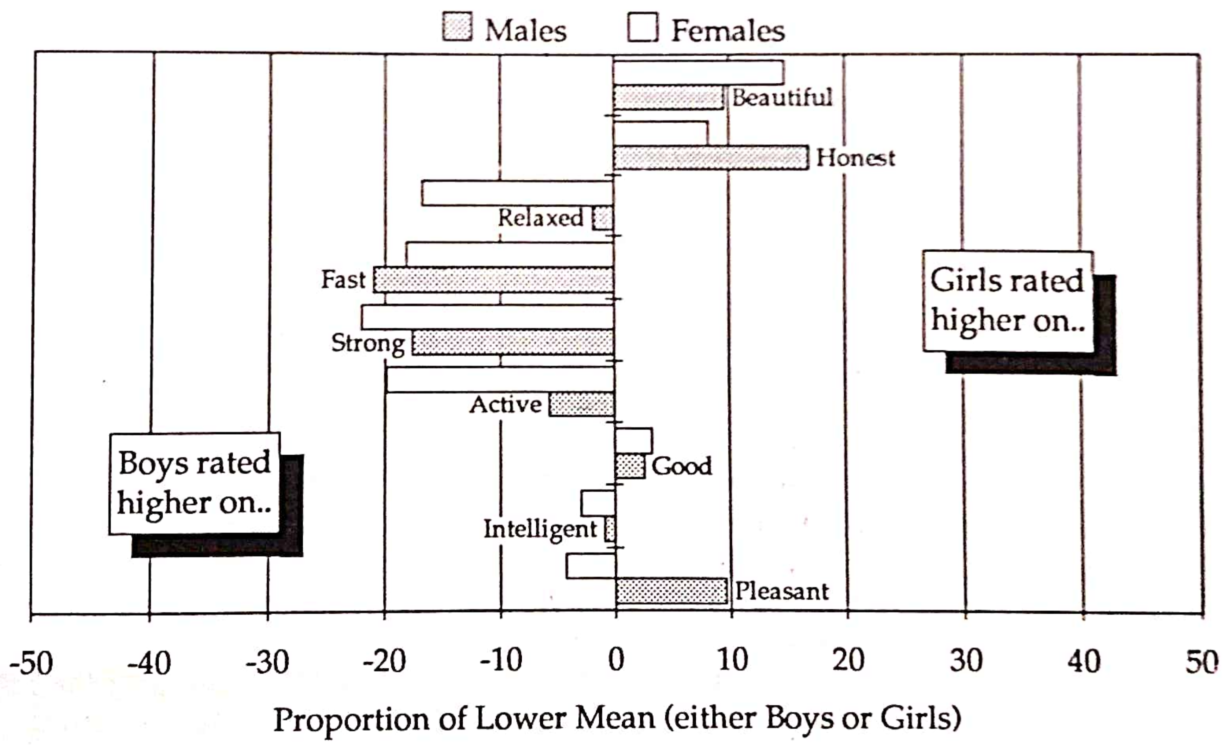



*Figure 8 Sex Bias/Deference: Muslims*



The contrasts are clear from the graphs. Females Defer on Strong and Fast much more than do Males show Bias on these characteristics. Importantly, Females Defer to the opposite sex on Intelligent. In fact, the difference between the strength of Male Deference and Female Deference on Intelligent is quite marked.

**Muslim** Figure 8 shows the graphs for Muslim Male and Female Teachers.

Again, the contrasts are clear from the graphs. In short, females Defer to the opposite sex on both the active characteristics and on Pleasant and Intelligent. The strength of the differences is most marked for Relaxed, Active and Pleasant.

**Discussion**

The graphs presented in the preceeding section do reveal differences between the groups of respondents based on Country, Religion and Sex. However these differences, of themselves, do not suggest specific actions which may alleviate any Sex Bias. Nor, indeed, do they provide indication of any external source of Bias. What, then, can be said of the information presented?

*Perceptions of Self*

Attitudes and perceptions form that class of phenomena which Kelly calls *personal constructs*[16], and it is that framework which guides the present study. Personal constructs are the mental structures which individuals employ in order to make sense of the world. They are, in this sense, personalized theories about the world: about things, events and people. The consequence of this view is this: if we ask individuals to give their perceptions of others we are asking them to indicate *how they think* about those others. Importantly, how we think about anything is linked closely with how we think about ourselves. When asked to think about others we project ourselves as the other: we reveal our biases.

If this view is applied, now, to the perceptions of Technical and Vocational Education Teachers which have been presented, the graphs may take on a different meaning. In particular, what is noticeable throughout all the comparisons, is that Female Teachers display greater Sex Deference than do Male Teachers. Equally of note, though, is that in some cases Male Teachers rate Girls higher than do Female Teachers: that is, Males Defer to the opposite sex more than Females show Bias on the same characteristic.

Although for some characteristics, including Beautiful & Pleasant, there appears no occupational relevance for others, such as Intelligent, Active and Relaxed, there is. For the latter characteristics, and in some of the comparisons, the difference between Male and Female responses is marked.

From the information presented it can be concluded that, in general, the difference between Male and Female Teachers in Technician and Vocational Education is that Females are more likely to display Sex Deference on the characteristics of the given scales. It is not the Males who are biased: it is the Females who defer.

*Meaning & Measurement*

In the original study the Semantic Differential scales were used as an adjunct to other measures of teacher perceptions. Thus, though data used here was from that study, the scales for Male Students (Boys) and Female Students (Girls) were not designed for an exhaustive analysis of the personal constructs of teachers. Yet the method of measurement has the distinct advantage that it invites examination of the meaning of responses *to the responder* – rather than to the object of the response.

There are limitations, however. One is the use of English words, and their connotations, in contexts where English is invariably not the native tongue. Another is the choice of terms to denote characteristics. Despite these possible cautions the responses do reveal a consistency which is both internal, in respect of the characteristics (Beautiful – Ugly, etc), and external, in respect of our appreciation of the differences between the sexes.

The Semantic Differential differs from other forms of attitude measures in one other important way: it permits a variety of analyses to suit a multitude of purposes. Exploration of Sex Bias and Sex Deference, for example, can proceed beyond the analysis presented here. Comparisons are possible between all combinations of variables and groups. Such exploration needs to be guided in some way but, that aside, few other measures enable the researcher to derive as much insight into the meaning of what respondents are saying.

The Semantic Differential was used in this extension study to determine this flexibility and its applicability to the question of sex bias in Technical and Vocational Education. Its use was exploratory, but also illustrative.

**Conclusion**

The purpose of this study was to provide an extension to prior research into the role of sex bias in TVE. The specific intent was to add meaning to the relationship between the respondents' country of origin, religious affiliation and sex.

Data from the original study were used to show respondent profiles on two scales based on the Semantic Differential. Profiles, in the form of graphs, were used to enable comparisons between country, religion and sex groups.

Though exploratory in purpose and limited in ways noted, the study reveals that one impediment to the full and equal participation of females in technical and vocational education may be that women do not think of themselves as equal partners in that enterprise.

It would be instructive to determine whether this conclusion can be corroborated, and I have suggested a particular way of theorising about teacher perceptions and a specific means of measurement which may be useful for such a purpose.

## REFERENCES

1. BASU, CK, ESPINO, IG & LANE, TI. *The Influence of Teacher Attitudes on the Schooling of Girls in Technical/Vocational Education in the Asia Pacific Region* Colombo Plan Staff College for Technician Education & UNESCO Manila. September, 1989.
2. Ibid. p 50.
3. Ibid
4. Ibid

5. ACKER, S (Ed) *Women and Education: World Yearbook of Education.* London. Kegan Paul. 1984.

6. WOOLLARD, J AND LOWE, M. *Women taking leadership in organization,* Training Officer August, 1988. 234-236.

7. BOSERUP, ESTER. *Women and National Development New York.* UNDP. 1977.

8. UNITED NATIONS *World Conference to Review and Appraise the Activities of the United Nations Decade for Women: Equality, Development and Peace.* New York. United Nations. 1986.

9. UNESCO *Equality of Educational Opportunity for Girls and Women* ED/83/WS/55 Paris. UNESCO. 1983.

10. VOSPER, K. Women into Technology *National Teacher for Further and Higher Education Journal* May, 1988.

11. PICKARD, A. Female students in technology *National Teacher for Further and Higher Education Journal* February, 1988.

12. EPPERSON, S.E. Classroom Bias Seen Spoiling Girl's Chances *The Asian Wall Street Journal* September 21, 1988.

13. See GREER, GERMAINE. *The Female Eunuch* New York McGraw-Hill 1971; DAVIS, ELIZABETH GOULD *The First Sex* London J M Dent & Sons Ltd 1971 & DE BEAUVOIR, SIMONE *The Second Sex* Harmondsworth Penguin 1972.

14. See, for example PELLATIRO, J. The Power of Positive Attitudes for Vocational-Industrial Teachers *Journal of Industrial Education* 26,3,1989. 59-61. and ROGERS,C CHARLES *Freedom to Learn for the 80's* Columbus, Ohio. Charles E Merill. 1983.

15. OSGOOD, CHARLES E, SUCI, GEORGE J AND TANNENBAUM, PERCY H. *The Measurement of Meaning* Urbana, Illinois. University of Chicago Press. 1967.

16. KELLY, G A. *The Psychology of Personal Constructs* New York. Norton. 1955.

# Establishing a New Specialized Course in Electro-Mechanics in Technical High Schools in Japan.*

S. FUJINAWA

*ABSTRACT*

*The paper reports the efforts of Japanese Technical High Schools in modernizing the contents of technical education with emphasis on electronic progress. School education is compelled to cope with the progress of Science and Technology and the tendency to improve the educational contents in the high school curriculum has appeared all over japan. This paper presents a plan for establishment of a course in Electro-Mechanics to improve the school curricula.*

## Introduction

Scientific technology has enormously progressed and advances in the field of electronics have brought dramatic changes in all industrial societies. This is particularly obvious in developments in the field of mechatronics where conventional mechanical techniques are combined with advanced electronic techniques. Rapid changes have been taking place in the processing machine industry as well. The introduction of automated machine tools, industrial robots, computer aided design (CAD) and other new developments have taken place in small and large companies alike.

In order to meet the needs of such a rapidly changing industrial field, it is necessary for technical high schools to place greater emphasis on education that provides the knowledge and skills to work in industrial and mechanical fields. Our technical high schools have planned and carried out various kinds of improvements relating to electronic practices such as production of circuit and computer operations.

But it is impossible for our conventional facilities and laboratories to introduce a large number of electronics fields in the school curriculum. Moreover, we need teachers who have good skills and knowledge in both electronics and mechanics.

In this paper, I suggest the establishment of a new course in Electro-Mechanics that combines traditional mechanical techniques with electronics skills. This will increase the level and efficiency of education not only in the mechanical field but in the related fields.

*The author acknowledges the inspiration provided by his academic adviser Dr. Ikemoto, President of Tokyo Kasei University, in preparing this paper and also for reading and criticizing the rough draft of the manuscript.*

I hope that this new course will contribute not only to educational improvements in Japanese technical high schools but also to advances in similar institutions all over the world.

## Establishing a Model Electro-Mechanics Course

In order to properly establish educational principles and courses in this field, it is important to first consider that, as it is a new educational area, it requires a completely new system and a course. Further, the educational techniques needed to coordinate instruction in this field have to be adequately organized. It is necessary to reexamine related high school courses currently taught in order to add new areas to the curriculum and remove areas that are no longer applicable or necessary. Special care must be taken to ensure that important areas are stressed, unimportant areas do not receive undue attention and nothing of importance is left out.

The correct combination of practical and specialized courses must be determined.

## Areas for Improvement

The following is an outline of the areas that must be given greater attention and those that should be withdrawn, when planning courses in Electro-Mechanics to meet the aims and requirements of providing a high standard of education in this important field.

### *Practical Training*

Among the many items that must be introduced in new courses, we can point to graphic programming with microcomputers, machine control with microcomputers, sensor and other electrical circuitry, measurement techniques, sequence and feedback control, programming general computer control, the use and management of NC machine tools, the use and management of industrial robots and system simulation.

In traditional mechanical education courses, over half of the practical training time is concentrated on developing manual skills in such areas as casting, forging, welding and operation of machine tools. These courses must either be totally eliminated or established as elective courses. The importance of such courses can only be considered with regard to the fact that the elemental techniques that they stress are important when considered as individual components of a comprehensive programme. While studying these components and gaining experience, students must be made to understand the ways in which they are interrelated and the roles they play in relation to the whole aim.

### *Drafting*

Traditional courses have devoted a great deal of time to teaching the basic features of manual drafting: foundation lines, characters, planes, three dimensional drawings and component charts. However, as a result of the increased use of CAD, graphic programming with microcomputers, idea sketches and other computer assisted techniques, the need for such manual skills has been all but replaced. Greater emphasis must be placed on teaching students how to use computers even for such tasks as creating drawings of machine systems and complicated apparatus.

### *Mechanical Design*

In addition to introducing computer techniques for use with the design of all mechanical elements, it is necessary to stress the importance of approaching design with a perspective that allows a flexible response to different situations. Even for transmission systems, the ability to design a simple mechanical structure is not sufficient. Where the problem concerns manual responses to electrical problems, oil pressurization, air pressure or basic electronic circuitry, students must be able to design circuits that meet the needs of the situation they are faced with.

*Basic Electricity*

Until now two units in General Electronics outside the electronics department were required. In designing a curriculum for an Electro-Mechanical course, the importance of similar courses to provide comprehensive training in electronics cannot be over-emphasized.

*Electronic Technology 1*

In order to teach the principles of apparatus used in mechatronics and to give students the ability to use these

Table A. General Subjects

| Subject Area | Subject | 1st | 2nd | 3rd | Total |
|---|---|---|---|---|---|
| Japanese | Japanese 1 | 4 | | | |
| | Japanese 2 | | 3 | 2 | 9 |
| Social Study | Contemporary Social Study | 3 | 1 | | |
| | Morals | | | 2 | |
| | World History | | 2 | | |
| | Politics & Economy | | | 2 | 10 |
| Mathematics | Mathematics 1 | 4 | | | |
| | Mathematics 2 | | 3 | 2 | 9 |
| Science | Science 1 | 4 | | | |
| | Physics | | 3 | | 7 |
| Health & Physical Education | Physical Edu. | 2 | 2 | 3 | 7 |
| | Health Edu. | 1 | 1 | | 2 |
| Art | Fine Arts 1 | 2 | | | 2 |
| Foreign Language | English 1 | 3 | 2 | 2 | 7 |
| Selective Subjects | | | | 4 | 4 |
| Total | | 23 | 17 | 17 | 57 |

Note: Figures show number of units in a year.Students on 3rd grade can choose 4 units among elective subjects such as Contemporary Literature, Classical Literature, Japanese History, Chemistry, English 2 and various professional subjects.

machines, it is necessary to establish such a course in the electronics department as a continuation of the skills learnt in Basic Electricity.

In particular, attention must be given to teaching the relations with Mechanical Design and to mastering design techniques. A foundation in sensors and applied circuitry is also required.

*Information Technology 1*

Computers are responsible for all automated machine tools, automatic apparatus and automatic production systems.

It is essential to teach computer skills in any Electro-Mechanics course. In addition to basic instruction on data processing programming techniques, it is necessary to teach computer graphics and measurement techniques, and programming skills for controlling elevators, robots and other apparatus.

**Example of an Existing Course**

An example of a course designed for teaching Electro-Mechanics in Tokyo Metropolitan Koganei Technical High School is given in Tables A through E. To meet the local needs, a great deal of emphasis is placed on mechanical and electronic techniques in the course. It may therefore be necessary to adjust this organization to the region where it is implemented.

Table B. Extra-curricular Activities

| Area | Activity | 1st | 2nd | 3rd | Total |
|---|---|---|---|---|---|
| Extra-curricular Activities | Home Room | 1 | 1 | 1 | 3 |
| | Club-Activities | 1 | 1 | 1 | 3 |

Table C. Professional Subjects for 4 Specialized Departments

| Specialized Department | Mechatronics | | | Mechanics | | | Electronics | | | Electricity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| School Year | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 1st | 2nd | 3rd |
| Foundation of Industry | 4 | | | 4 | | | 3 | | | 3 | | |
| Practice | | 5 | 6 | | 5 | 6 | | 4 | 5 | | 4 | 5 |
| Drawing | 2 | 2 | 2 | 3 | 3 | 2 | | 2 | 2 | | 2 | 2 |
| Industrial Mathematics | 1 | 2 | | 2 | 2 | | 2 | | | 2 | | |
| Mechanical Work | | | 2 | | 2 | 2 | | | | | | |
| Mechanical Design | | | 3 | | 3 | 2 | | | | | | |
| Prime Movers | | | | | | 3 | | | | | | |
| Basic Electricity | 2 | 2 | | | | | 4 | 4 | | 4 | 4 | |
| Electronic Technology 1 | | 2 | | | | | | 3 | 4 | | | |
| Electronic Technology 2 | | | 2 | | | | | 2 | 4 | | | |
| Electric Technology 1 | | | | | | | | | | | 2 | 4 |
| Electric Technology 2 | | | | | | | | | | | 3 | 4 |
| Information Technology 1 | | 2 | | | | | | | | | | |
| Total Units | 9 | 15 | 15 | 9 | 15 | 15 | 9 | 15 | 15 | 9 | 15 | 15 |

Note: Figures show number of units in a year. Mechatronics: Electro-Mechanics

Table D. Elective Practices for Mechanics and Electro-Mechanics Departments

| Practice Name | Practice Contents | Apparatus ( ):Number |
|---|---|---|
| Personal Computer Application | 1. Programming in BASIC Language<br>2. Algorithm of Flow-Chart<br>3. PASCAL Language<br>4. Assembler Language | Personal Computer (20)<br>Printer (11)<br>X-Y Plotter (2)<br>Digitizer (2) |
| Electronic Working | Electronic Circuit Working<br>1. Production of Power Sources<br>2. Selective Application Work | Oscilloscope (15)<br>Power source (15)<br>Measuring Instruments |
| Basic Electricity | 1. Theory of Alternative Current<br>2. Logical Circuit<br>3. Production of AC-Motors &DC-Motors<br>4. Home Electrics | Breadboard (12)<br>Power Source-5v- (6) |
| 3-Dimensional Drawing | 1. 3-Dimensional Drawing<br>2. Computer Aided Design | Drawing Devices (16)<br>Personal Computer (16) |
| Application of Mechanical Working | Production of Oil Jack | Machining Center (1)<br>Milling, Special Jigs |
| Industrial Arts | 1. Industrial Design<br>2. Wood Work 3. Pottery | Wood Lathe(5), Plane<br>Electric Furnace (1) |
| Welding | Welding Application Works using Gas, Arc and Inert-gas Welding | Welding Devices of Gas, Arc & Inert-gas |
| Prime Movers | 1. Car Maintenance Work<br>2. Air Conditioning Work | Oscilloscope<br>Maintenance Devices |
| Numerical Control & Personal Computer | 1. Application of MC<br>2. Application of Welding Robot | MC, Welding Robot<br>Personal Computer |
| Information Processing | 1. FORTRAN<br>2. Assembler | Personal Computer (20)<br>Printer (10) |
| Application Work of Control Skills | Production of Automatic Conveyor driven by Microcomputer | One Board Micro-computer 1/0 Board (14) |

Table E. Practice Contents in Electro-Mechanical Department

1st Grade (4 units)

| Practice Name | Hours | Practice Contents | Main Apparatus |
|---|---|---|---|
| Mechanical Work 1 | 140/3 | 1. Basic Operation<br>2. Production of Screws<br>3. Production of Hammer | Lathe(14)<br>Drilling Machine(2)<br>Centering Machine(2) |
| Electronic Circuit 1 | 140/3 | 1. Assembling of Tester<br>2. Electronic Measurement<br>3. Electronic Circuit<br>Logic-Checker | Tool Sets(15)<br>Tester(15)<br>Power Source(15)<br>Interface(5) |
| Information Processing | 140/3 | Personal Computer Exercise<br>1. Fundamentals of BASIC<br>2. Graphic & CAD<br>3. Application Works | Personal Computer(16)<br>Printer(7)<br>X-Y Plotter(3) |

Note: One class consists of 40 students, divided into 3 groups. One group can study 3 kinds of practices a year by rotation. One unit has 35 hours a year.

2nd Grade (5 units)

| Practice Name | Hours | Practice Contents | Main Apparatus |
|---|---|---|---|
| Mechanical Work 2 | 175/3 | 1. Production of V Block<br>2. Welding<br>a.Gas Welder, Arc Welder<br>b.Welding Robot<br>3. CNC Machine Control | Milling machine(5)<br>Shaper(2), Grinder<br>Welding machine(20)<br>Welding Robot(1)<br>CNC Milling Machine |
| Electronics Circuit 2 | 175/3 | 1. Electric Circuit<br>2. Semiconductor<br>3. Semiconductor Circuit<br>4. Logical Circuit<br>5. Application Work | Oscilloscope(15)<br>DC Power Source(15)<br>Transmitter(15)<br>Resistor(30)<br>Variable Condenser(7) |
| Computer Control | 175/3 | 1. Hardware of Computer<br>2. Software of Computer<br>3. I/O Board Control<br>4. Stepping Motor<br>5. Application | Microcomputer Training Module (15)<br>One Board Computer(16)<br>I/O Board(16)<br>Logic Analyzer |

3rd Grade (4 units)

| Practice Name | Hours | Practice Contents | Main Apparatus |
|---|---|---|---|
| NC Working Machine | 140/4 | 1. Numerical Control | Machining Center(1) |
| | | 2. Programming of NC | Automatic Programming System(6) |
| | | 3. Automatic Programming | |
| | | 4. Simulation of Working | X-Y plotter(2) |
| Electronic Circuit 3 | 140/4 | 1. Sequential Control | AC-DC Power Source(15) |
| | | a.Mechanical Control | AC Motor, DC Motor (15) |
| | | b.Nonarcing Relay | Sequential Control Training Board(15) |
| | | 2.AC Motor Control | |
| Application Work by Computer | 140/4 | 1. Motor Control Devices | Stepping Motor kits(3) |
| | | a.Stepping Motor | DC Servo Motor Kits(3) |
| | | b.DC Servo Motor | Handling Robot(3) |
| | | 2. Basis & Application of Programmable sequencer | Personal Computer(3) |
| | | 3. Control Devices | Programmable Sequencer |
| | | | Conveyor Robot(1) |
| | | a.Robot | Drilling Machine |
| | | b.Air Control Devices | Controlled by Computer |
| Mechanical Experiment | 140/4 | 1. Metal Material Test | Universal Testing Machine(1) |
| | | a.Tension Test | |
| | | b.Heat Treatment | Metal Microscope(3) |
| | | c.Metal Structure | Electric Furnace(1) |
| | | 2.Industrial Measurement | Hardness Tester(4) |
| | | a.Basis of Measurement | Surface Roughness Tester(1) |
| | | b.Surface Roughness | |

## Improvements in other Vocational Education Areas

### *Agricultural Education*

Agricultural processes for growing vegetables and flowers have become more and more mechanized. One area that is receiving focus is agriculture in controlled environments that provide ideal lighting, humidity and temperature. Such controlled environments are monitored by automated systems. It is necessary to teach students the skills required to operate, maintain and manage such automated environments. This can best be accomplished by providing instruction in basic electronic techniques that are at the core of the automatic systems that control these agricultural environments. One option is to take courses in automation and basic electronics directly from industrial fields.

It may also be appropriate to use such courses as a reference to create counterparts that are geared to agricultural training. In the light of the increased use of electronic techniques in food processing plants, it is advisable to examine the above courses and create similar courses to meet the particular needs of a comprehensive food processing plant.

### *Marine Production Education*

One vital area in the field of marine fisheries is radio communication. Although instruction has been provided in special fields that are related to electronics, this is an area in which advances in electronic technology are occurring at a rapid pace. In order to keep pace with this, it is important to provide as much education and training as possible in fields such as computers and basic and new electronic techniques.

Plants that process marine products have adapted a great deal of automated technology in the areas of freezing, storing, processing and production. As the future is sure to see even further advances in the level of technology that governs these machines, it is important to provide a firm grounding in computers and related areas.

### *General Education*

Among general eduction courses, classes in Physics involve practical training related to electronics. In cases where courses in physics are required, it is advisable to include electives in areas such as Basic Electricity, Information Technology and Information Processing. It may be preferable to use such courses as basis for developing similar courses that are better designed for the specific Physics programme.

Depending on the particular case one might also consider including a course such as Fundamentals of industry. This kind of course provides instruction covering the areas of electronics mentioned above.

## Conclusion

I have suggested concrete examples of organizing curricula in Electro-Mechanics in Technical High Schools to cope with the technological changes taking place. I believe that this paper is useful to know the present status and trend concerning industrial education in Japan. I will be happy to receive from readers any useful suggestions on the points discussed in this paper.

## REFERENCES

*MINISTRY OF EDUCATION* (1983). Report of the Electronics Section of the Committee on Industrial Education.

## Subject-based Package Approach to Staff Development*

BARKI, B.G.

*ABSTRACT*

*This paper describes an innovative approach to training technical teachers using a Subject-based package approach. This approach aims at developing a range of teaching competencies in teachers through a pre-prepared subject-based package integrating content and methodology. The paper reports the outcomes of a try-out of this approach for training teachers of technician mathematics.*

### Introduction

Technical education in India has witnessed phenomenal expansion during the recent years in terms of number of institutions, intake of students, number of teachers etc. This is matched by provision of additional resources and facilities in the laboratories, workshops and resource centres to respond continuously and effectively to the demands placed on them. Influenced continuously by the technological and scientific changes, diversification of courses, modernizing of curricula, opening of new institutions and staff development to respond to the changing situation have been taken up. Thus this vital sector of education has been able to make a significant contribution by providing the right type of personnel to organized and unorganized sectors of industries.

This sector of education is poised for further growth and development as the country prepares itself to move into the 21st century. The system is gearing itself to meet this challenge by developing in the students abilities and attitudes required for building a dynamic, vibrant and cohesive nation capable of providing its people with the wherewithal for creating a better, fuller and more purposeful life. The greatest challenge in this complex and exciting task will have to be shouldered by the teachers, notwithstanding the efforts that are expected to go into improving all other aspects of technician eduction system such as curriculum development, instructional material and media development. Staff development, therefore, becomes a very important aspect in improving this system.

### Teacher Training

It is accepted that an efficient teacher is always in a better position to provide his learners with an appropriate instructional environment which helps them to develop the talents, techniques and temperament necessary for adapting themselves to the

*Paper presented at the Asian Regional Conference (AIAET) held at Trivandrum (India) in November, 1989.*

demands of fast technological changes. Training of such teachers must receive the highest priority in planning technician education. Not only is it vital for the technical teacher to possess relevant personality traits but also professional skills, including high positive attitude towards the teaching profession. Some of the crucial questions relating to teacher training often raised are:

— What are the mechanisms available for training technical teachers?

— What are the aims and objectives of the training programmes?

— Do the training contexts take into consideration the natural situations existing in the teachers' institutions?

— Are the trained teachers capable of adapting and transferring the knowledge and skills acquired during training to their natural environment?

**Current Practice**

Currently there are no pre-service training programmes to train technical teachers in India. In-service training programmes of varying nature-long term and short term-are offered by Technical Teachers Training Institutes (TTTIs) to provide for subject updating and also help the teachers to acquire competencies for effective classroom teaching. Short courses in areas such as skill development, evaluation of student performance, curriculum development, student personnel administration etc. are organised with a view to enable them to acquire abilities in these areas. The long term programmes for training polytechnic teachers are mostly modelled on the lines of training programmes for secondary school teachers. Because of the non-mandatory nature of these programmes, they are not often taken seriously.

Periodic feedback obtained from the teachers during training and after, principals of institutions, administrators and others who form the clientele have revealed the following deficiencies:

— Competencies acquired during training are very rarely put into use (particularly in activities related to classroom teaching)

— Transfer of competency from the training situation to its use in the natural setting of the participants is often marginal.

— Materials and media developed and made available are not being optimally utilized.

— While the trainees generally display a more favourable and positive attitude in dealing with students, the gain in competencies is not seen to be generally displayed in effective classroom teaching.

— The transfer and retention of the acquired competencies for use during instruction is reported to be of short duration. Retention for longer periods of time is reported to be not very satisfactory.

— The contribution of trained teachers to improve the efficiency and effectiveness of instructional processes has not been significant.

A careful study of the above situation in relation to cost-effectiveness of the training programmes points out that the returns from training programmes is not commensurate with the investments made on them, although finding out the same is not very easy. Investment on training has always been considered as along term investment. It is essential that steps are taken to arrest this trend from the point of view making the training programmes cost-effective.

**Limitations and Causes**

This situation was carefully studied and the causes for the same were analyzed. The following causes have been identified:

* There is a general shortage of teachers leading to over-loading of existing teachers, leaving them with very limited time to plan, develop and use appropriate competencies.
* Lack of adequate support services and basic facilities in the institutions act as constraints for wider use of instructional resources.
* Encouragement and guidance from the educational managers and administrators is inadequate
* Various programmes of TTTIs such as teacher training, staff development and instructional material and media development appear to be inadequately integrated in order to provide the supportive and reinforcing requirements of these programmes for producing cumulative effects.
* The various components of long term teacher training such as subject updating, pedagogy and industrial training are organised without linkages which are strong enough to develop a range of integrated competencies in the trainees.
* The ability of the teacher trainees to transfer the generalized competencies acquired by them to teach specific subjects/topics, taking into account the constraints and other operating conditions that are prevalent in their institutions, has not been developed to a meaningful level.

**Alternate Programme**

The need to remedy the situation hardly needs reiteration. Viable training approaches which include in them methodologies which are user-friendly and participant-oriented and which take into consideration the existing environment in the user system must be developed. In evolving such approaches the following important considerations which have a bearing on their effectiveness must be kept in mind.

* Inadequacies in facilities and resources in polytechnics would be major hurdles in implementing any programme, although constant efforts are underway for improving the facilities in the polytechnics. For reasons well known, such a situation is likely to prevail in the institutions for a long time.
* People are known to work in situations which do not call for heavy investment of time or efforts on their part. However, where activities do not demand any special efforts, they can be expected to give a fair trial to any new idea or approach. This is particularly true in situations where teachers are required to shoulder many responsibilities and have a fairly high work load hindering them from planing for a new activity and implementing the same.
* Teachers will try out new approaches and transfer the competencies gained during training to the classroom in their natural setting, if there is no risk of failure. They have a tendency to play safe.

* Teachers will use the materials and media in their instruction, if these are available in adequate numbers and are suitable for covering the prescribed units of study.

In consideration of the above, it becomes essential to evolve a training programme which has the components of content, methodology, materials and media which are appropriately integrated. The programme must be aimed at enabling the teachers to acquire the necessary competencies in various aspects of teaching through the medium of a specifically developed package. The package must be the one which is capable of being used in the natural classroom instruction.

**SBPA Programme**

A new approach called the 'Subject-Based Package Approach' (SBPA) is conceived for training technical teachers. This programme is aimed at getting over some of the drawbacks of the conventional training programme. The main objectives of this approach are to

* enable the teachers to understand the methodology of developing instructional packages
* enable them to use prepared instructional packages for teaching specified subjects with an emphasis on improving the effectiveness of instructional processes
* provide them opportunities to try out the package in simulated situations
* develop in them an integrated range of competencies in content, methodology and performance assessment, leading to proficiency in teaching specified subjects

*Salient features of the programme*

The SBPA works towards training teachers in the effective use of instructional packages and to concentrate on the implementation of these use-wares, thus ensuring the realisation of qualitative standards of the instructional processes. For this purpose, suitable training programme of a short duration is designed, implemented and constantly monitored to develop proficiency in teaching identified subjects with the extensive use of pre-prepared instructional packages in the relevant subjects and to ensure adoption of appropriate methods and resources on a continuing basis resulting in the improvement of quality of instructional processes.

It is reasonable to expect classroom teachers to constantly keep themselves abreast of the growing knowledge in the areas of specialization. Obsolescence in subject matter is a great disadvantage for teachers. Relevance of the content inputs to the industrial processes and practices is the hall-mark of any technician curriculum and the students must be constantly exposed to industrial facilities. This can be achieved if the teacher trainee becomes familiar with industrial practices. A host of instructional methods from lecture to Computer Assisted Instruction and Interactive video instructional systems are in practice at different places. However, teachers must choose the appropriate method keeping in mind the facilities available, the nature of the subject and students, time available and other constraints and restraints. They are also responsible for assessing the performance of their students for the explicit purposes of finding out to what extent they have been able to achieve the instructional objectives spelt out. Such evaluation may have to be both formative and summative. Their performance must be assessed not only in the theory subjects but also in practical work. This calls for teachers to possess satisfactory level of competency in assessment of student performance.

*Steps in Planning*

After careful and serious deliberations the following stages were identified for planning, implementing and monitoring the SBPA training programmes.

STEP 1: DEVELOPMENT OF APPROPRIATE INSTRUCTIONAL PACKAGES

Pre-prepared Instructional packages will be the principal medium for developing proficiency among teachers for teaching identified subjects. The package will consist of:

— an operational course content. This includes the objectives of the unit, teaching points lesson wise, suggested activities for achieving the objectives (such as lesson presentation on concepts involved, classroom assignments with feedback for consolidation, home assignments, teaching learning resources (print as well as non-print) and indicators/assessment to find out the extent to which the objectives have been realised.

— lesson material containing teaching points, approaches for lesson presentation, details of examples, feed-back questions, assignments and conclusion. These make the task of the teacher simple.

— media such as transparency sheets, slides, audio and video cassettes for use in the normal classroom setting.

— unit test and assignment sheets for administration at the end of the class.

In developing the package it would be necessary to integrate content and methodology including practical work in the laboratory and assessment of student performance. The prevailing curriculum in an identified subject, the most effective methods and appropriate media for instruction vis-a-vis the prevailing situations and environment must be considered so that the package may be put to use in polytechnics and is feasible for adoption under the obtainable working conditions. In this process, possible alternatives with their philosophies and underlying theories must be carefully considered. Flexibility of the methods and media to suit any specific teacher and any specific group of students is also allowed for and in-built into the package. The relevant material and media are also developed and included as part of the package.

STEP 2: TRAINING PROGRAMME

Having developed the subject-based package, the next step is to train teachers to enable them to acquire the required competencies for effective teaching. The main focus of this step is to concentrate on the user-ware and ensure the realisation of qualitative standards of the instructional processes. The training programme will be of a short duration of about 6-8 weeks and will have all participants from any single discipline, with 30 as the maximum number. The programme will be designed to facilitate mutually beneficial interactions and appreciations of the problems and issues in teaching the subject. It will concentrate on treating all the components of teaching (such as content updating, choice and use of instructional methods and media, industrial experiences through exposure to industry and industrial visits, evaluation etc) not independently or in isolation. Opportunities for interactions and discussions with the faculty, simulated exercises, laboratory work, field visits would be provided towards enabling trainees to internalize the relationships among the different components and their articulation in implementing instruction. By the very nature of the programme which is intensive in nature and subject-oriented, it can be expected to offer great promise of ensuring adoption of appropriate methods and resources on a continuing basis.

**TTTI Madras experience**

In tune with its constant efforts in experimentation and innovations, TTTI Madras tried out the SBPA for staff development through a short term programme in Mathematics.

*Implementation Strategy*

* The topic 'Differential Calculus' in the common core subject Mathematics was considered for the preparation of the package for the programme for training Mathematics teachers.
* The package was developed by a team of faculty specialists in the subject.
* The package includes the content in the chosen topic, the content being self-sufficient and self-contained. A brief introduction spelling out the importance of the topic, development of the teaching points in a logical order, exercises and worked examples, classroom assignments for consolidation and feedback and follow up activities are contained in the content. An operational course content outline giving details of the specific objectives of each lesson of the unit, lesson-wise teaching points, suggested mode of lesson presentation including the activities and exercises, required teaching learning resources and assessment procedures is included in the package. In suggesting the most appropriate mode of presentation (method to be followed) various methods of presenting the content to the students are considered and the one which is possible for implementation within the institutional constraints is suggested. The package also contains related media such as OHP transparencies and details of student activities, required worksheets and assessment sheets.
* The training programme focussed on the participating teachers to acquire the skills and competencies of teaching with the subject-based package as a medium.

The Training package in Mathematics on the topic Differential Calculus comprised of the following four units:

Unit 1: Functions and limits

Unit 2: Methods of Differentiation - I

Unit 3: Methods of Differentiation - II

Unit 4: Application of Differentiation.

The faculty developed pre-prepared packages for three units viz., 1,2 and 4. It was decided to involve the participating teachers to prepare the package for unit 3 during the training programme with a view to enable them to understand the method of preparing a package.

The SBPA was tried out in a two week short course offered at TTTI Madras. The course was attended by senior teachers from the Southern Region. As a course input the participants discussed the various components of the package. They critically reviewed the pre-prepared package for its relevance, adequacy, and appropriateness. Component skills essential for teaching were identified and they were guided to acquire these skills. This package was tried out under simulated conditions, following a demonstration on teaching by the course faculty.

### *Outcomes*

The following are the outcomes of the programme and the package approach:

— Enhanced competencies for effective teaching of the topic, involving integration of content and methodology to cover aspects such as directing, correcting, reinforcing and evaluating learning.

— A validated instructional package on the topic which can be used by the teachers in their own institutional settings to facilitate effective learning by students.

## Conclusion

The Subject-Based Package Approach is thought of as a viable alternative to the conventional type of long term training and short term training programmes. The SBPA takes into consideration the need for developing pre-prepared subject-based packages and training the faculty of institutions by using these packages to develop the required competencies for effective teaching of their subjects.

## ABOUT OUR CONTRIBUTORS

**AFUGBUOM E.C.**

Mr. AFUGBUOM EMEKA C is a lecturer in the Department of Science Education at the Anambra State Polytechnic, Oko (Nigeria). He is a biologist and has a long experience of teaching in his country. He is an active member of professional bodies like Science Teachers Association of Nigeria (STAN) and Science Association of Nigeria (SAN)

**BARKI B.G.**

Dr. BARKI B.G. is a Professor of Education at Technical Teachers' Training Institute, Madras (India). His teaching and research interests are in the areas of staff development, guidance and counselling and instructional design. His publications include a Manual on Guidance and Counselling, monographs on micro-teaching, distance learning modules in educational psychology and instructional design, besides research papers. He has organised several training programmes for technical teachers and engineers from industries.

**DAVID CHANTRILL**

Mr. DAVID CHANTRILL is a mechanical engineer with research experience in the field of heat transfer and is presently a Faculty Consultant at the Colombo Plan Staff College for Technician Education, Manila (Philipines). He is a member of the Institution of Engineers, Australia and the British Institute of Nuclear Engineering. He has worked as a Consultant on training aspects of development projects in several Asian and Pacific countries and has also been engaged as a Project Appraisal and Evaluation Specialist by the Australian Development Assistance Bureau. He has conducted a number of staff development programmes for member countries of Colombo Plan and undertaken consultancy assignments for international agencies such as UNESCO, ADB and SEAMEO. He has published several papers in engineering and technical education fields. He is a member of the Editorial Board of this Journal.

**FUJINAWA S.**

Mr. SHUICHI FUJINAWA graduated from the master's course of Technical Education Section of Tokyo Gakugei University (Japan). He is at present a teacher in the Tokyo Metropolitan Kaganei Technical High School and a lecturer in the Department of Engineering at Seikei University. He served as an Expert on Automatic Control to establish an Electronics Institute in Riyadh (Saudi Arabia) during 1988-89.

**PASSMORE D.L.**

Dr. DAVID L. PASSMORE has been aVisiting Scholar at the Injury Prevention Research Center, Department of Maternal and Child Health, Harward School of Public Health, Boston (U.S.A.). He is now back at the Pennsylvania State University, University

Park (U.S.A) as Professor of Vocational Education and Adult Education in the College of Education and the Dean of its Graduate School.

**TERRY LANE**

Dr. TERRY LANE is currently the Faculty Consultant at the Colombo Plan Staff College for Technician Education, Manila (Philippines). During 1974-84 he was working in the Department of Administration & Higher Education, University of New England, Armidale (Australia). He was the Principal Education Officer (Computer Education), Department of Education, Northern Territory, Darwin (Australia) during 1984-86 and then served for a year as a Consultant on Information Technology, Darwin (Australia) before moving to Colombo Plan Staff College, Manila in 1989. His current interests are in the applications of computers to instruction and management in technician education.

**WOLANSKY W.D.**

Dr. WILLIAM D. WOLANSKY is a Professor of Industrial Education and Coordinator of International Programs at Iowa State University, Ames, Iowa (U.S.A.). He has published several books and articles in industrial education and has worked as a Consultant to governments and educational institutiòns in Nigeria, Jamaica and Taiwan.

**YEN-FEI HWANG**

Dr. YEN-FEI HWANG is an Associate Professor in the Department of Machinery Manufacturing at National Yunlin Institute of Technology in Taiwan. He has recently concluded his study at Iowa State University, Ames, Iowa (U.S.A.)