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The recognition of the growing interdependence between vocational-technical education and industry is a major feature of the educational history of our times, but much of the planning work in vocational-technical education is still limited to general studies of historical data or to the analysis of alternative programs. The educational planner-administrator needs predictive quantitative models which can be used to identify longterm technological changes. Not all administrators, however, are willing to consider and be constrained by the requirements of the occupational purpose of their products. The problem, then, is to develop a system which would coordinate occupational requirements and occupational-technical education planning objectives. Three central "follow-up" considerations to the objectives of a vocational- technical education planning process are (1) ensure that action follows policy, (2) develop improved understanding of technological developments among administrators, and (3) give primary attention to those generic-system environment relationships which are affected by planning decisions. (Author/HW)

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TECHNOLOGICAL CHANGE AND EDUCATIONAL OBSOLESCENCE:

CHALLENGES TO ADMINISTRATORS AS MANAGERS OF CHANGE

This paper is attuned to three major areas of concern:

1. The impact of technological changes on the occupational structure;
2. critical issues in developing improved understanding of technological developments, including automation; and
3. implications for the vocational-technical education planning process as the vehicle for accomplishing system change.

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ABSTRACT

Although a dialogue has been initiated, within recent years, between scientific analysts and educational planners, much of the planning work in vocational-technical education either is still limited to general studies of historical data or addresses itself to the analysis of alternative programs.

The thesis has been developed that the educational planner-administrator needs strong predictive quantitative models which are suitable for testing and which have cross-technology capability, linking technology with economic feasibility. These could be used to identify long-term technological changes.

Not all administrators are willing to consider and be constrained by the requirements of the occupational purpose of their products. The problem, then, is how to develop a system or set of sub-systems which would facilitate the syndromization of occupational requirements and occupational-technical education planning objectives.

Three central "follow-up" considerations to the objectives of a vocational-technical education planning process are: to ensure that action follows policy; to develop in administrators an improved understanding of technological developments, including automation; and to give primary attention to those generic-system environment relationships which are affected by, and which in turn affect, planning decisions.

To the extent that recent technological developments emphasized the need for long-range planning, a systems look as outlined in this paper may provide a methodological basis for interdisciplinary, planning-oriented research. The paper concludes with comments on the possibilities and limitations of vocational-technical education planning and its integration in a broader framework of social planning.

I

The recognition of the growing interdependence between vocational-technical education and industry is a major feature of the educational history of our times. Modern industry rests upon a level of competence which is supplied through technical education at various levels. At the same time, no educational system can supply the required level of skills and competence without receiving the active support of industry. This view reverts at once to the main theme of this paper: namely, the kind of occupational training and technical education the American school system should supply and its constant renewal and development by reference to changes not only in knowledge but in the manpower needs of industry as well.

Given today's relationship between manpower problems and technological changes, it is rather alarming to observe that the efforts of technological developments have neither become an area of primary research concern within colleges and schools of education, nor is there a concensus regarding the impact of technological change on curriculum. As a matter of fact, there seems to be little agreement on the interpretation of the term "technological change."[1]

Higher technical education as well as vocationally oriented training have for many years ignored technological changes; they have persisted in preparing students for a world viewed from an inherited, oftentimes locally oriented outlook. Educators have only recently recognized the need for a positive attitude toward space-age technology; thus, constructive ideas have been developed regarding the adjustment of vocational and technical curricula in order to prepare students for their role in the world of tomorrow.

Perhaps the most important theme running through this paper is a sense of urgency concerning the measures and attitudes to be adopted by educators and administrators.

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[1]"Technological change" is defined here in its more technically precise form; it considers two dimensions of change: (a) the technical dimension and (b) the economic-social dimension.

"Technical change is not to be identified with science and discovery. Science gives us knowledge and power for action. It tells us what we can do. Research seeks out the practical and the more or less practicable. Technological change, however, reflects the actual adoption of new methods and products; it is the triumph of the new over the old in the test of the market and the budget.

"Technological change, apart from discovery, is a complex, economic and social process which is influenced by a range of decisions by business enterprises, labor organizations and workers, national and local governmental agencies, the educational system, households, and by the values and attitudes of the whole community. No single body makes a decision as to the rate of technological change in the society, no law can increase it by simple decree." Definition by John T. Dunlap (ed.), Automation and Technological Change (Englewood Cliffs: Prentice-Hall, 1962), p. 4.

The system of vocational and technical education must be endowed with the necessary capacity for change and innovation so that it can adequately respond to the legitimate pressures and demands from modern society.

Technological changes in the past few years have made the relationship of education to our economy not only much closer than in earlier decades, but also more visibly related to the rate of economic growth as well as the life-time earnings of the labor force. One of the many aspects of the relation of the economy to the educational system lies in the connections between occupational structure and the size and character of vocational-technical education. As industry is undergoing rapid changes in its occupational structure and as technological change and automation raise the skill level of jobs, the educational system must also undergo a dynamic expansion. Obviously, there are some connections between these broad developments. On theoretical grounds alone we are tempted to suggest that changes in the occupational structure of industry do have measurable effects on our technical education institutions because the new demand for educated personnel quickly transforms itself into higher enrollments.

There is also a new interest in educational planning. All the evidence suggests that the tide of education is mounting with extraordinary rapidity. One expects, for instance, that in the next ten years the American higher education system will double. This development will be accompanied by higher costs. The rise in expenditure is justifiable in view of the fact that not only many more people with highly developed skills and abilities will be needed, but that this economy requires a work force, which can adapt itself to ever-changing circumstances. As the economy requires a greater output of qualified manpower, it is impossible to meet that demand without having consequential changes and adaptions through the educational system.

II.

As far as the scope of this paper is concerned, it would be misleading to suggest that "neat" conclusions to critical issues will be developed which will improve the understanding of technological developments and their effect on the economic structure.

While an attempt shall be made to examine technological change as it bears upon education, it must be recognized that many of the findings are based on hypotheses pertaining to specific and technical situations in various geographical areas and that these premises must be tested against the characteristics of their context of application.

For the educational decision-maker the relationship between labor and technological changes should be of great concern, as he needs to understand the implications of curriculum revisions in the light of technological changes and the far reaching consequences of unemployment.

The introduction of new techniques of production eliminates some jobs (affecting labor requirements) and, also, eliminates occupations (creating changes in skill levels). However, it must not be overlooked that, at the same time, new jobs and new occupations are being created.

Current labor market data suggest that "there are basically no inherent long term difficulties in the technological disemployment problem, provided responsible managements give warnings of employment changes or facilitate adjustments internally through retraining or transfer and provided a high level of aggregate effective demand is maintained by government through its fiscal and monetary policies."[1] Thus, for the economist with deep interest in the economics of education it is somewhat reassuring that the most significant employment implication of automation is not mass unemployment.

Concerning the contribution of technological change to current or short-term instances of unemployment, the general level of unemployment needs to be distinguished from the displacement of particular workers at particular times and places. In a recent study Gannon writes that "Changes in the general level of unemployment are governed by three fundamental forces: the effective growth of the labor force, the increased labor productivity (i.e., output per man hour) and the growth of total or aggregate demand for goods and services. The general level or aggregate demand for goods and services is the prime

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[1]See Colin A. Gannon, et. al., An Introduction to the Study of Technological Change and Its Consequences for Regional and Community Development (Evanston, Illinois: The Transportation Center at Northwestern University, March 1967), p. A-146.

factor in determining the general level of employment and unemployment.

"Technological change affects all three of these major forces, but its main <u>effect</u> is registered (incompletely) through the rise in productivity."[1]

The basic relationships involved are illustrated in the following formula:

$$g_D = (g_p + g_L - d_h) - g_u \qquad (1)$$

where g_L = effective percentage growth in the labor force,

g_D = percentage growth in effective demand for output,

g_p = percentage growth in average productivity,

d_h = percentage decline in total hours worked per year, and

g_u = percentage of growth in unemployment rate.

Gannon concludes that "only when total production, (g_D), grows faster than the rate of labor force growth plus the rate of productivity increase, does the employment rate rise (g_u increases), and hence the unemployment rate falls. For example, for the economy as a whole, if the rate of growth of productivity is 3% per year, the labor force grows at 1.9% per year, and average hours worked per year decline at 0.4% per year, then from equation (1) above:

$$g_D = (3 + 1.9 - 0.4) - g_u$$

$$\text{i.e., } g_u = 4.5 - g_D \quad \ldots\ldots \qquad (2)$$

[1] Ibid., pp. A-101-A-103.

Equation (2) above simply tells us that total output (and the aggregate demand to buy it), must grow in excess of 4.5% per year just to prevent unemployment from rising."[1]

The economist who wants to assist educational administrators in decision-making needs predictive models suitable for testing. The development of such instruments should make it possible to predict the effects of technological changes on occupations. Our position is that a mathematical model of technological change, i.e., a systems model, is necessary to make predictions. Such a model is not easy to construct because of the scarcity of explicit quantitative data on variables involved in technological change. In fact, many economists have expressed their view that the derivation of a complete, closed and predictive systems model is impossible.

Focusing on automation and its effects on the occupational structure, we are forcefully reminded that one of the great research omissions in the United States was the absence of government sponsored research in predicting the future of machine counterparts as substitutes for human information-processing. Until recently data on technological and economic availability of these counterparts, had also been overlooked. Research in this direction will provide the basis upon which predictive instruments for future changes in occupations and job contents can be built. Crossman remarks that only when a matrix of information processes and machine counterparts has been developed <u>then</u> the forecasting of future

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[1] *Ibid.*, pp. A-101 - A-103.

changes in technology can be undertaken.[1] Studies of specific responses which technological processes at the various stages of automation require of skilled personnel may provide the skill information that is needed. A cross-technology investigation of required responses will permit the identification of broad skill categories which in turn could be used for developing suitable guidelines for vocational training and technical education.[2]

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[1] E. R. Crossman, "European Experience with the Changing Nature of Jobs Due to Automation," (Mimeo., University of California, Berkeley: Department of Industrial Engineering and Operations Research, December 1964).

[2] See Louis E. Davis, "Discussion of the Impact of Automation on Occupational Distribution, Job Content, and Working Conditions," (Mimeo., University of California, Berkeley: Department of Industrial Engineering and Operations Research, January 1965).

III.

Much, but not all, of the current educational planning work in the United States is dominated by the social demand approach.[1] The usefulness of this approach for curriculum planning in vocational-technical schools and in colleges and universities is limited by the uncertainties in the relationship between particular occupations and the education that they require. Changes in technological processes may require a change in the educational input for particular occupations, while changes in content and methods of education affect the educational input for relevant occupations.

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[1] Four definitions for social demand as abstracted from some of the recent writings in the field are:

1) "Social demand for education means the effective demand for places in formal education."

2) "Social demand for education is the eminent need of the democratic society (present and future) for the improvement of human capacity by formal and nonformal education."

3) "Social demand for education is an expression of securing equal chances for all individuals to get all the education they can absorb," or similarly

4) "Social demand for education means the demand derived from the principle of giving all individuals an equal opportunity to get all the education they ask for."

(See Friedrich Edding and Jens Naumann, "A Systems Look at Educational Planning," in Richard H. P. Kraft (ed.) Education and Economic Growth (Tallahassee, Florida: Educational Systems Development Center, 1968), pp. 130-160.

Factors such as the appeal which various curricula have upon students, e.g. preference for arts or sciences instead of engineering, necessitate a revision of forecasts, and the constraints in this sector may again lead to a revision of the curricula. In any case, more refined forecasting techniques, particularly long-term ones that are used in identifying the impact of technological changes on skill requirements and demand for labor, are needed.

At the same time, a regular evaluation of the <u>relevance</u> of technical curricula to the educational input into the labor market is required. Our recent inquiries in the Southeast revealed an insufficient refinement of the first type of data and the almost complete absence of valid data on the second type.[1]

Under these circumstances, and in light of the persisting uncertainty which is inherent in educational planning, the only general conclusion which we can draw from the social demand approach is an appeal to all educational decision-makers to adapt the structure, methods, and content of technical education to the new situation of fluctuating labor market requirements. The answer to this problem should not be sought in better forecasting techniques alone but in the curricula themselves.

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[1]These inquiries will be discussed in a later section.

The status of vocational-technical education in the eyes of many industrialists is changing at the present moment. Some firms are quick to see that the educator is a valuable ally while the attitude of others remains more traditional. Although industry, seen as a whole, is more rapidly recognizing that the efficiency of production is in the end merely the efficiency of the producers, there is still the fear that the processes of education may bring forth some undesirable by-products. After all, many industrialists remember that education has a strong literary tradition, and while it had trained men for responsible administrative positions many have either positively despised the skill of the profit-oriented manager, or deliberately kept themselves in ignorance of the market forces and of economic laws.

No one can deny that there is cleavage between the academic world, on the one hand, and the vocational world on the other. It can be seen in the incompatibility between the intellectual and the trade-union wing of the political parties; it turns up inside education itself as the contrast between the "university" and the "State college" and between the various post-high school vocational-technical education institutions and the system of part-time vocational-technical education.

These are all examples of an antithesis between the learned and labor that enters deeply into the whole of human society. The deep gap between "vocational" and "academic", thus, is by no means a figment of the imagination. It is real, and a great number of educators and educational administrators are deeply concerned as they see it widening.

How is it significant in the training and education of skilled labor in a changing labor market? First of all, it means that there must be recognition of the fact that occupational training is a respectable role for post-high school institutions, such as junior colleges. Sometimes it seems as if certain segments of our system of higher education price themselves out of the market by unduly emphasizing the nevertheless important academic programs.

The higher order of tasks in American society becomes more and more complex with each passing year, and at the same time the lower order tasks are being relegated to machines. The vast array of middle-order tasks will soon furnish the livelihood for the majority of American citizens. The development of area vocational-technical centers and junior colleges is dependent on how successfully they are able to solve the problems of education and training for these middle-level tasks.

Somehow the system of vocational training and technical education must provide a continuous educational spectrum to match the continuous occupational spectrum. For example, a trend of engineering colleges has developed to avoid extreme specialization since many of them regard the vast spectrum of jobs at the technical level as consisting of clusters of jobs. Curricula in these institutions are usual , planned for one or more of those clusters.[1]

Also, in intermediate technical education a spectrum of jobs is involved. Surveys have found technical jobs which range across a wide spectrum: those where technicians work at a quite highly sophisticated level in research, and those occupations that demand a great deal of manipulative skill and ingenuity with tools and equipment, but require only a modest background in science, mathematics, and engineering theory.[2]

The important point of this finding is that there are all kinds of technical jobs between these extremes. The gap between the professions and skilled trades cannot be filled by one kind or level of qualified personnel. It is here, where many educational planners and junior college administrators in charge of curriculum, commit a grave error. In their determination to be "academically respectable,"

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[1]Typical job fields or clusters are: civil technologies, mechanical technologies, electrical-electronics technologies, and industrial technologies.

[2]See also Charles S. Benson and Paul R. Lohnes, "Public Education and the Development of Work Skills," Harvard Educational Review, XXIX (Spring, 1959), pp. 137-150.

they plan programs only for engineering technicians, raising the level to a point where it barely differs from that of an engineering program in a college of engineering. Many administrators tend to defend this curriculum by arguing that the public image of American technical education is one in which occupational training hardly belongs to the educational world at all. It is seen instead as a minor ancillary of the world of industry.

Regarding occupational and educational relationships three points should be stressed: First, if the educational planner-administrator wants to adjust the curricula in response to technological changes, planning strategies and activities must not only throw new light on the efficiency of firms with regard to their personnel policies, but educational planning must also take a comprehensive look at educational qualifications, the cost of education, and the problem of malutilization of educated labor in various segments of industry.

Secondly, to be realistic, educational planning, which involves the use of detailed occupational and educational data, must revise its outdated approach in terms of rigid educational requirements for technical occupations. Research showed that, par example, for engineering jobs no single educational qualification or educational "avenue" stands out as the "optimum" education for that particular occupation.

Finally, the administrator in charge of curriculum revisions must realize that firms invest in their educated labor in much the same way as in their physical capital. Inquiries showed that large manufacturing firms in Florida, for instance, plan the use of highly qualified personnel over time in the same way as they plan the use of capital. These companies have recognized that it is of utmost importance to predict the rate of progress of automation and the accompanying changes in skill input.

Within the framework of what sometimes is called "active labor planning," these firms have already worked out plans to predict the employment at various skill levels that will be required in the future.[1]

Confronted with oftentimes conflicting calculations regarding the future occupational structure of the labor force, the educational

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[1] The execution of these plans requires technological (or engineering) expertise; it requires economic analysis and also a great deal of psychology. In order to predict employment due to technological changes in the future, management wants to know:

a) the present technological methods used for the production of the complete line of products;
b) the new processes and methods that are in the making;
c) how fast each new technological development will spread and how large the percentage replacement of each currently used method by a new one will be; and
d) what new skill inputs will be needed, and what the "skill input profile" will look like.

planner-administrator will have to solve the problem of translating the labor requirements by occupational categories into requirements by educational qualification. Undoubtedly this constitutes a main difficulty since there seems to be no stable relationship between the occupation a person has and the schooling he has received.

Davis is very much concerned about solving this problem and outlines some suggestions for the development of predictive instruments which might help the educational planner-administrator in initiating appropriate curricular changes. He separates short-term changes in occupations and skills from long-term changes. In order to obtain the necessary data, he proposes an intelligence network which would consist of "information links with a selected sample of representative employers, private employment agencies, unions and governmental agencies. This intelligence network would provide reports about changes in selected jobs and their contents."[1]

Davis continues that "this network would permit the development of comprehensive information on changing occupational employment patterns in individual industries. Continued sampling of jobs and tasks selected on the basis of an automation taxonomy and subjected to study will permit the identification of changes in skill patterns within jobs. As a predictive instrument, the short-term indicators can be tested when complete and comprehensive data are

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[1] Louis E. Davis, op. cit., p. 8.

available at longer time intervals."[1]

For the educational planner-administrator long-term changes in occupations and skills are even more interesting. In his paper Davis points out that the "identification of long-term changes requires the development of predictive instruments having cross-technology capability and linking technology with economic feasibility. This would require us to begin with a . . . formulation of an automation taxonomy."[2]

In an earlier study a quite different approach was used. Age-earnings-education profiles were constructed showing that the rate of monetary return was higher at the technician level than at the engineering level. Even though some of the data are inadequate, it is tempting to conclude that the large earnings-differential might well lead to a higher demand for educational services at the intermediate (technician) level. In view of the forecast of a changing skill profile, the need for a better differentiation between appropriate functions of vocational-technical education centers, comprehensive high schools and junior colleges should be emphasized because this seems to be an urgent requirement in order for educational services to meet industrial needs.[3]

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[1] Ibid., p. 9.

[2] Ibid., p. 10.

[3] Richard H. P. Kraft, "Inter-Firm Correlations: The Contribution of Educationally Heavy Inputs to Increasing Profitability," Education and Economic Growth, editor Richard H. P. Kraft (Tallahassee, Florida: Educational Systems Development Center, 1968), pp. 112-129.

IV.

It is a well-known fact that the literature on the economics of education, and more specifically, on technological changes is by no means scarce. However, there is a shortage of relevant empirical material. Thus, our recent research[1] had two aims: to stress data collection and, as a consequence of the empirical aspects of our research, to formulate new conceptual tools.

During the interview phase of an industrial depth survey, officials of a representative number of firms reported that technical curricula must reflect the most up-to-date knowledge in particular subjects. In order to take account both of the increase in the amount of knowledge and the rapid change in its nature, a continuous revision of courses is required. At the same time there is a limit to the amount of material which can be accommodated within courses. The extension of technical schooling, which has resulted from the awareness that man in modern society needs more basic knowledge and preparation, cannot in itself solve this problem. This dilemma has reinforced the concept that the role of post-high school vocational-

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[1] Richard H. P. Kraft, Education and Occupation: Manpower and Changing Industrial Skill Requirements (Tallahassee, Florida: Educational Systems Development Center, 1968).

technical education is not to offer even more knowledge, but, instead to select from the vast stock of knowledge that which is essential. Such a technique should enable the student to develop the aptitude for acquiring and using knowledge on a continuous basis.

In order that there be a receptive audience for new developments the educational planner-administrator needs to cultivate the right attitudes in his faculty. When the educator accepts innovation they will be more easily incorporated into the regular process of education itself. It is only in this way that teaching can become an instrument not only for the dissemination of knowledge but for its production, especially in higher education.

An exploration of the awareness of industry's officers and technical institution's educators and administrators to technological changes revealed that in most cases the question of education and technological development had been given careful thought. The technological changes up to now had not been of a kind to induce smaller and middle-size firms to make any special investigation. They expressed the opinion that it was not possible to distinguish technological changes from other simultaneously influential factors behind movements in the manufacturing industry.

The economists in the firms that were investigated agreed that there are no instruments to aid in predicting the kind and extent of educational changes that will be necessary in the future. They felt that the lack of a systematic frame of reference has contributed to the issues regarding technological change and the ensuing curricular changes as they are affected by various broad policies and policy decisions.

Almost all interviewees (90 per cent) complained that in vocational training and in technical education, "change is too slow in getting accepted." Complete diffusion of successful innovations appear to take "a decade" after the first introduction. In defense of many outstanding post-high school institutions, other representatives mentioned that the rate of acceptance has, however, recently increased considerably.

This acceleration can be observed not only in the introduction of primarily technical innovations, but also in organizational changes and in curriculum materials.

Somers is of similar opinion and calls for an analysis of procedures usually adopted in reaching decisions on the initiation of new vocational-technical education programs. He reports that

> the established procedure for beginning a new course is for the school's director or coordinator to utilize the services of an advisory committee, either a standing group or one appointed ad hoc for this purpose. The committees are to be composed of employer, union, and public members. Although the pressure for establishment of the course may initially come from the school staff, from a group of employers in the community, or from students who wish to enroll in such a course, it is the responsibility, first, of the advisory

committee and then of the implementing school officials to evaluate the real present and future need for such a course on the basis of the best labor market data available.

...Having determined the need, the decision to go ahead will presumably depend on costs and available budget, and on such practical considerations as the availability of space and equipment. Once the school authorities are convinced of the wisdom of the new course, they must then persuade local and state education boards.[1]

It was interesting to note that all interviewed representatives of industry associated the major problems in vocational-technical education with the absence of appropriate mechanisms to initiate changes and with the need to develop attitudes which would make innovations more acceptable. It is largely as a consequence of new and recent change in attitude towards vocational-technical education that educators at post-secondary institutions have been encouraged to think of educational changes as a continuous, rather than periodic, process, a "rolling" adjustment to technological changes.

It seems to have been fully recognized that scientific and technological changes not only affect the content of the material, but also the attitudes and habits which should be developed.

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[1] Gerald G. Somers, "The Response of Vocational Education to Labor Market Changes," Vocational Education, Supplement to the Journal of Human Resources, Vol. III, 1968, pp. 53-54.

In view of possible revisions of the curricula, it is felt that educators at vocational-technical institutions should think primarily of providing generalized basic courses rather than specialized subjects with currently fashionable names and content. Strengthening mathematics and the physical sciences will have to serve the needs of technological changes, including automation.

A large number of educational planners-administrators in vocational-technical institutes and junior colleges expressed a view contrary to the opinions of industrial representatives. They feel that technical education need not, and perhaps in many cases ought not, to be directed at meeting the technological changes which determine the manpower requirements of the various industry groups. More than 90 per cent of the respondents expressed their strong feeling that technical education -- including the training of highly qualified technicians -- should focus on establishing a broad intellectual foundation which then would enable the student to identify and solve problems he encounters at work.[1]

This view ran contrary to the opinions expressed by the first-, second-, and third-level supervisors and top-level industrial officers who were interviewed. Over 70 per cent of the respondents indicated

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[1]See also Samuel M. Burt, "Conducting Manpower Skill Needs Survey," Industry and Vocational-Technical Education (New York: McGraw-Hill Book Co., 1967). He reports the laments of vocational-technical school directors and advisory committee members concerning the lack of employer cooperation in providing pertinent data on manpower needs.

that technical education "beyond the high school" should meet the specific needs of industry. And 60 per cent of the interviewees added that short-term needs ought to be served by vocational-technical institutions. Thus, employers in manufacturing firms, in transportation, communication, and public utilities, who would generally like to see a wide and broad-based curriculum arrangement, expressed the need for specialists.

The views on the balance between the "theoretical" and the "practical" side of engineering education undoubtedly vary at the numerous institutions in different states. In the Southeast 80 per cent of faculty members interviewed at schools and colleges of engineering,[1] believe that industry brings a "certain amount" of pressure to bear on colleges and universities in adjusting their technical curriculum to the specific training requirements of individual companies.

Although the pressure exerted by companies in such circumstances is understandable, the opposite position is more justifiable, since the effect of technological change often is unpredictable, university work should constitute an essentially academic education. In practice, however, such a sharp contrast between the two parts of engineering education is seldom emphasized. It was felt that the main task of colleges of engineering is to educate engineers academically and to make specific arrangements with industry so that practical

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[1] N = 62.

training will be "related" to the students' educational progress.[1]

V.

During the past few years, the engineering profession has been faced with increasingly new and extremely complex problems. All result in a need for educational program-planning.

Manufacturing processes either are or are becoming extremely complex; advances require the young technician or engineer to have an education based both on the engineering sciences and the pure sciences. The scientific training of past years was founded on the pattern of slow evolution of individual development in pace with the existing transition rate from discovery to application. This pattern just does not exist anymore, thus,

> the coupling of this factor with the ever-increasing fund of knowledge results in an unquestioned need to reorganize training methods to incorporate more of the scientific approach to engineering. This includes not only an increase in emphasis on fundamental principles and mathematical tools, but also instruction in the use of these principles and tools in their application to engineering problems.[2]

More than 75 per cent of the educators and administrators who were interviewed anticipate that automation -- or for that matter, any

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[1]While this combination of academic education and industrial training is deliberately designed for students who plan to make their careers in the manufacturing industry, it must not be designed to serve only the more limited goals of a particular industry or company.

[2]Herbert S. Parnes, "Manpower Analysis in Educational Planning," Organization for Economic Cooperation and Development (ed.) Planning Education for Economic and Social Development (Paris: Office for Scientific and Technical Personnel, 1963), p. 50.

technological change -- will be less likely to come as a tidal wave, but rather as a succession of groundswells that will reach different operations and industries at different times and with different impacts. The same staff members mentioned three built-in brakes that should stay the spread of automation in the manufacturing sector to a pace that will not overtax the firms' abilities to absorb it. These three governors are (a) the technical limitations of the design to automatic applications, (b) the limited economic feasibility of automation, and (c) managerial inability to fully understand and take advantage of the opportunities which automation presents.

In designing a "proper" program, engineering faculties find themselves in a dilemma since their students are bound to engage in widely varied types of work. After all, engineering students may be divided roughly into five general groups:

a. The engineer-scientist:
These engineers are creative and devote their major attention to the discovery of new facts about engineering systems and to the recognition of those scientific facts which will lend themselves to engineering development.

b. The creative engineer:
These are the individuals who actually design new engineering systems and put newly discovered principles to use.

c. The functional engineer:
These are the engineers who employ orthodox methods and established principles in the design of conventional details of manufacturing plants and public utilities, and they build, operate, and maintain these plants and the related equipment.

d. The engineer technician:
Engineers in this group devote their attention to the more routine tasks such as testing, inspection and analysis.

e. Engineering graduates in non-engineering work:
A large number of engineers in each of the above categories find themselves, perhaps ten years after graduation, in administrative, executive, or ownership posts in industry, government, and utilities.[1]

Since management realizes the need for highly qualified technical personnel to be trained in general management, much of industrial management training is carried out internally by the larger manufacturing firms. Only a small number of educators that were contacted (10 per cent) expressed doubts about the quality of training offered in industrial institutions. The majority feel that certain firms at present can impart more knowledge to their technicians and engineering staff than academic institutions can.

As the rate of technological change in manufacturing, contract construction, communication and public utilities increases, the need for more cooperation between those industry groups and technical institutions should grow.[2]

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[1]Herman A. Estrin (Ed.), Higher Education in Engineering and Science (New York: McGraw-Hill Book Co., 1963) p. 52.

[2]A recent survey showed that 21 per cent of manufacturing firms advertise in local newspapers to make adjustments to the shortage of qualified personnel. Only 17 per cent, however, contact the local school system and ask school officials to establish specific training programs. For specific data see Richard H. P. Kraft, Education and Occupation, op. cit., p. 40.

Several engineering colleges in the Southeast have designed a core of courses in engineering science common to all engineering curricula. It was interesting to find that 50 per cent of the interviewees saw great merit in emphasizing general principles, whereas the other half of the sample opposed the core curriculum on grounds that specialties should not be incorporated into a common course and taught to engineering students as a whole. A more fundamental, or undergraduate, instruction would be desirable but a "single basic curriculum" would be unrealistic because of the diversity of sciences on which engineering practice rests. Several colleges of engineering were criticized by industry for having offered courses or clusters of courses which have little or "no reference to the application of special knowledge in industry."

All large firms in the sample provide special technical training for their qualified employees. Only 10 per cent of all company officials saw any danger in the reliance on internal technical training, but 65 per cent of the academic staff members pointed out that there are two basic danger-zones. First of all, the on-the-job training tends to be, often enough, of a very narrow kind; and secondly, not enough new ideas are getting into the company, thus, a large amount of information and knowledge may be given but with little or no reference to technological changes.

VI.

There seems to be general consensus among educators and educational administrators that the need for a broad and well-structured technical education curriculum does not arise solely from humane idealism, but rather from urgent practical economic needs. It is thought that the adjustment of the educational structure to technological change is an essential basis for any attempt to prepare this country intelligently for the educational tasks that lie ahead.[1]

This represents a potentially serious philosophical conflict between the new manpower interest in education and the traditional view of education's role in a democratic society.

Under the "old" view, the purpose of education was to enable the individual to equalize his full human potentialities for his own sake; in the light of the social demand approach, however, industry, as well as cultural and public institutions, have to be staffed with

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[1]As pointed out earlier, the effects of technological changes are by no means rigidly determined by technological factors. These set certain limits to the kinds of development that can occur, but within these limits there is enough room for considerable variation. Technological changes, thus, offer us freedom of choice in such matters as curriculum changes and job design. From another viewpoint it can be seen as less advantageous since human inertia and the complicated procedures of changing and existing curriculum might prevent us from reaping the full benefit of these changes.

persons having the requisite education and skills.[1]

Specialists engaged in educational planning must consider this conflict carefully. One of their major tasks is to convince statesmen, educators and educational administrators that this conflict is not irreconcilable and that the two educational objectives could be balanced.

The survey data indicate that technological change and, in particular, the development of automation did not involve any serious considerations concerning a closer cooperation between industry and vocational-technical training institutions and schools of technical higher education. More than 20 per cent of all answers received from academic staff members indicated that technical education ought to see its main function in the development of fundamental knowledge, a role not easily reconciled with specific industrial requirements. In a similar vein, sections of industrial officers (19 per cent) show a lethargy and have not seriously considered how vocational-technical education centers and colleges of engineering might assist

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[1]See also Philip H. Coombs, "Educational Planning in the Light of Economic Requirements," Organization for Economic Cooperation and Development (ed.), Forecasting Manpower Needs for the Age of Science (Paris: Office for Scientific and Technical Personnel, 1960), p. 26.

them in acquainting future staff members with technological change.

The present lack of interest by industry seems to be an indication that only to a very limited extent does it recognize the possibility of influencing the curriculum structure.

Such predictive instruments as described above may be capable of providing the educational planner-administrator with information having long-term implications. The planning specialist not only would be in the position to identify those skills most likely to be replaced in future years, but the instruments would also assist him in projecting long-term educational needs. Such forecasts, then, would provide the needed support for the development of a long-range vocational-technical education policy.

VII.

Two research projects related to technological change and the responsiveness of vocational training and technical education to this change provided the bases for the tentative and, sometimes limited, conclusions of this paper. It would seem that at the same time we have raised a number of questions of considerable significance for the further development and improvement of the study of vocational-technical education and the use of qualified manpower by industry. An attempt has been made to show that further and more comprehensive research is desirable from both the local and national viewpoint. This research would yield important information on which educational administrators could base further action relating to the formulation of occupational and educational relationships in order to better adjust the curriculum to changing industrial manpower needs.

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