STRUCTURAL CHANGES IN TECHNOLOGICAL TRAINING MOTIVATED BY THE REVOLUTIONARY EXPANSION OF PURE AND APPLIED RESEARCH

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The revolutionary transformation of science and technology started some decades ago.

Gaining in depth and width in our days, it has a considerable say in determining the ways to acquire the knowledge necessary for professionals in technology and research workers in science. The four to five years' span of university training, anchored on the "classical" type elementary and secondary education, released the graduates with a diploma authorizing them to "free practice" in their profession. Contemporary development, however, in science and technology, necessitates the revision of this classical type of education and calls for knowledge to be continuously acquired and supplemented far beyond the graduation.

In other words, gathering of scientific and technological knowledge demands a continuous addition of new knowledge, new relationships within old knowledge; a rapid replacement or revision of outdated knowledge. The quantity and quality of the increasing stock of knowledge would prolong the period of acquisition to such an extent that serious efforts have to be made in order to find new forms of continuous acquisition of knowledge to meet the requirements of our era.

Two different aspects seem feasible for analyzing the impact of this phenomenon on the training of professionals.

a) Within a relatively short time all essential factors of this revolutionary transformation (the so-called revolution in science and technology) must be surveyed. This survey would create a reasonable fundament for drafting the basic principles for a *completely new structured* ("ideal") system of education. With a forecasted validity of at least 15 to 20 years it would range from elementary education up to one's degree. Deliberate stress is laid here on the unavoidability of remoulding the *structure*, both as to contents and methods, for selection on the basis of aptitudes and for enabling the young candidates to assimilate the "new" in their respective field.

b) It is necessary to elaborate the step-by-step *transitional* stages, likely to provide a *gradual* transformation of the *actual* practice in scientific and technological training into the *anticipated* educational system set on a completely new basis, mentioned in item *a)*.

This must be done reckoning with the substance and method reality of the training system established as "modern" during the past fifty years, and which is pregnant with a tremendous inertia.

Both of the above aspects weigh equally. Otherwise, higher education would seriously conflict with the rapidly developing scientific methods in production and/or, on the other hand, the methods changing in the wake of the revolution in science and technology would necessarily contradict the unaltered traditional structure of the university.

— It follows from the above that the supervision of the curricula and methodology of the whole educational structure (especially its part preceeding university admittance) is indispensable in order to ensure the new type of university level training necessitated by the revolution in science and technology.

— Education primarily has to aim at developing independent thinking; making acquainted with and inspiring a liking for the concepts of mathematics, physics, chemistry (biology) at an early age; to further a scientific attitude and capability for abstraction at the most receptive age (from 12 to 18). This aim is helped by the dissemination of methods that reckon with the manifoldedness of the individual: the introduction and wide usage of modern facilities enabling a considerable reduction of the time taken up by mechanical study might serve as a significant link in the structure of higher education of up-to-date conception destined to train the professional of the 1990's.

Where the structure for higher education in natural and applied sciences is concerned, integration of sciences on the one hand (multiplication of border areas and amplification of "interdisciplinary" phenomena) have to be counted on, on the other hand, the factually or seemingly opposite requirement for specialized knowledge restricted to a narrow area for a perfect production's sake must be considered.

In our opinion this contradiction exists, withoutb eing necessarily antagonistic. No solution can, however, be generalized to embrace all fields or a protracted period. The qualifications and number of researchers in the border areas or of specialized technologists can only be determined for individual fields, for different stages in technical development and its tendencies (integration and differentiation), for a comparatively short period.

From the aspect of the coming decades, this presentation strives to question mark such a reorganization of the educational structure which would polarize university training into utterly different groups: training a small number of "elite" chiefly for research activity, and training of technologists for restricted fields of activity, respectively.*

* The author here is partly in contradiction with some of his earlier views, he considers this, however, to be the natural consequence of recent changes. (Scientific World No. 7, 3.3. 1959.)

Science and industry — developing in part parallelly, and in part in the wake of scientific achievements — are changing at an extreme rate. As a result, the university trained professionals** or at least their overwhelming majority must acquire a knowledge, or — more exactly — must be girded with a scientific and technological faculty of reception, which ensures convertibility through a periodical, short-cycle post-graduate training.

An educational structure formed along these lines would better concert with the revolutionary pace in science as such, without pre-determining the life of the individual with scientific and technical abilities. It would present a sharp contrast with the previous, idealized notion of a polarized university training for research and for technology, separated already during the studies.

Upon reconsideration of the idea faintly outlined above the following advantages of university type higher education founded on this base would appear:

i) The selection of candidates must be based on an essentially higher standard than what is required presently. During the 4—5 years of training the student should undergo a profound study of basic and some major aspects of applied sciences without any particular specialization.

ii) The work of the university does not end at the graduation. After the first few years spent by the graduates at work they are to be encouraged to specialization by post-graduate training of the kind related to their work and/or sphere of interest. *Universities have to be evident guardians for these post-graduate courses*, of an extreme manifoldedness both as to duration and contents. Polarization — an outdated scope of training, — would thus be replaced — or sublimated — by repeated and — shall we say — "escalated" specialization.

This system would make any kind of narrower and/or deeper specialization the task of post-graduate training. It would completely span the professionally active time of most professionals by helping them to adapt, diversify and convert — according to requirements — a substantial part of their basic knowledge.

iii) From a psychological point of view, defects inherent with a too early specialization, likely to degrade technical professionals — of otherwise good abilities — over 30 years to inappropriate posts where their abilities cannot accomplish, could be avoided.

iv) An educational structure along these lines could further a rapidly increasing co-operation between universities, research institutes and industry — scientific and technical factors of equal importance in modern society.

** It ought to be stressed that the paper deals with "University level training" exclusively. The problem of other types of training institutions like technical colleges of high standard ensuring the decisive number of specialists to industry is an acute one and should be discussed elsewhere.

Thinking in perspectives, even an organic relationship of these three main components could be approached.

v) A similar training and post-graduate training system for professionals, aiming at the integration of higher (university-type) education, research and industry, though with inherent potential dangers, would present an opportunity to decidedly contradict the nowadays rather popular view (axiomatically taking that the consequences of the revolution in science and technology lead to "obsolescence of knowledge within a five year's periodicity — in the final analysis — might lead to a sort of scientific impotence because of the limited capacity of human mind". These views stimulate "scientific panic" and are likely te generate the feeling of "scientific anarchism" among students and would-be scientific workers. Such views might easily initiate acting to overturn at a stroke established scientific institutions. Supposing that scientific knowledge has a five years' cycle of obsolescence (and renewal), in our opinion any kind of panic may be avoided if universities train the *right persons in basic sciences and provide them with the right way of thinking in scientific categories.* This knowledge of theirs will then always be adaptable, convertible and versatile.

The accomplishment of an abrupt change of the institutions for university-type higher education formed during centuries and gaining their present form in the last few decades (i.e. period of the development of the new scientific revolution) and bound to an extremely heavy inertia without a carefully designed training model, could lead to a situation where *higher education becomes stranded on no man's land between the "old" — becoming obsolete organizationally and methodically — and the "new" not being carefully and consequently outlined yet.*

Summary

The revolution in science and technology has brought a serious crisis to higher education, requiring significant and far reaching alterations of methodology, organization and contents in the training of scientists and technologists, in order to cope with the requirements of society and rapidly developing industry. Transition has to be planned by reckoning with the trends in scientific and industrial development, projecting the whole structure of education at least two decades ahead.

The actual tendencies to polarize into research worker versus technologist at university level should be replaced by unified training in the main branches (mechanical engineering, building, electrotechnics, electronics, chemistry, etc.) based on sciences, educating to scientific thinking and to do individual work. Graduation should be followed by a series or cycles of post-graduate courses throughout one's career.

The structure of training and post-graduate training requires at the same time a closer co-ordination between university, research and industry.

"Professional training" cannot be perfectly synchronous to the "revolution in science and technology". Without far reaching planning; without reckoning with the whole conceivable structure of education included the different post-graduation activities reaching far beyond graduation, a radical change would fail the optimum for either the individual or the society.

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