Education and the Scientific and Technological Revolution

The paradox we are facing is this — the traditional system of education takes 12-20 years to prepare people for life, that being the usual time span accepted today, and this preparation has actually to equip people for life fifty or more years ahead, because their active lives will last that long; but the methods we use correspond to today’s and not to the future stage of development. We have no choice — either we have to comprehend the perspectives to that extent and direct training for life accordingly,101 or we assume implicitly that life in the future will be much the same as it is today, or perhaps that changes in human abilities will play no substantial part in future civilisation processes — in other words, we project the present aspect of the world and its industrialisation processes into future decades, abstracting from the nascent scientific and technological revolution and the social transformations of our day. And to the extent that this picture is divorced from reality, we shall be confining society within its present dimensions and making education a drag on the future progress of civilisation.

The type of work and the way of life prevailing in a society make their imprint through various media on the level of education and vice versa. The educational groundwork enforced by the industrial revolution as appropriate to its needs — and to which it confined the bulk of the population102 — was general versing in the three R’s (basic-type school) and elementary knowledge for manual skills (middle-type school), in short, mainly attainments making simple labor power suitable for manipulation in the factory.103


102 Up to the nineteen-thirties, a majority in the USA, and in the industrial countries of Europe 80-90 per cent of the active population, had no more than basic education usually lasting 8-9 years. P. F. Drucker (The Landmarks of Tomorrow, London 1959, pp. 146-7) therefore distinguishes between "a literate society" and an "educated society".

103 "... the most essential parts of education ... to read, write, and account, can be acquired at so early a period of life that the greater part even of those who are to be bred to the lowest occupations have time to acquire them before they can be employed in those occupations." (Adam Smith, An Inquiry into the Nature and Causes of the Wealth of Nations, Chicago-London-Toronto-Geneva 1952, p. 342).
"Civilisation at the Crossroads"

This is a section of the new Australian Left Review publication *Civilisation at the Crossroads*: the social and human implications of the scientific and technological revolution.

*Civilisation at the Crossroads* is a book which reveals the springs of dissent and revolution in modern society, the book behind the bid for socialism with a human face.

It was compiled on the initiative of the Czechoslovak Academy of Sciences by an interdisciplinary research team of 45 men and women each eminent in their own field, headed by Radovan Richta, one of Czechoslovakia's most famous marxist philosophers.

The aim was to confront in their totality the changes in modern society, and to this end economists, philosophers, psychologists, biologists, architects and educationists probed such topics as the new place of the human factor in production, new models of economic growth, a strategy for science, new modes of thinking and so on.

Here we reproduce the section of the book dealing with the conclusions of the authors on the need for great changes in education and their approaches to these changes which are dictated by the progress of the scientific and technological revolution. The need for educational reform is increasingly felt in society today, though the motive forces impelling change are not so often understood.

If readers take this section as typical of the quality of the book as a whole, which indeed it is, we feel sure they will want to study the whole 336 pages of it.

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For almost half a century — from the time when compulsory school attendance had become general in the industrial countries — the level of education and its predominant type showed little substantial change. From the thirties, and still more the fifties however, the educational systems of all industrially mature countries have been on the move. The spread of high schools, vocational schools, universities and colleges, and of out-of-school education, heralds a break that may be denoted as the onset of a new cultural revolution. Linked with technological advance and the onset of changes in the general conditions of human life, this revolution can be compared in scope to the introduction of universal elementary education, but its implications go much further, because the course of events today is giving education a new status in the life of man and society. The transformations are assuming the nature of a cultural revolution in its own right, with no direct dependence on advances in technology.

The past twenty to thirty years have seen an upswing in secondary education with a vocational bent, or with an emphasis on general education. The high school, or secondary school that not so long ago was still for the elite, is now generally accessible. In some countries (USA, Japan, Holland, Sweden, Finland), the bulk of young people now attend high school — 60-90 per cent of the age-group (see Table 2-10). In the USSR and Great Britain, secondary education for all is planned for the seventies, in France for the eighties. The probability is that many industrially advanced countries will reach this stage in the course of ten to twenty years. On this assumption, the close of the century will see an advance in the share of people with full secondary education from 15-20 per cent in developed European countries, and from 40 per cent in the USA in the early sixties (see Table 2-11) to a decided majority of the economically active population.

The past ten to twenty years have witnessed a notable expansion of the university population. Around 1963, university and college intake for full-time study (see Table 2-10) was 34 per cent of each annual age group in the USA, 15-20 per cent in the USSR, Canada and Australia, 12-14 per cent in France and in leading

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104 From the eighties of last century (when compulsory school attendance had been enacted in most countries) to the thirties of the present century, the proportion of students in the population was more or less stable; recent decades have seen an upswing. In the USA, of course, the explosion started earlier (Cf. J. Auerhan, *Technika, kvalifikace, vzdělání*, pp. 265-6).


107 According to C. C. Killingsworth’s data (see *Nation’s Manpower Revolution, 1963-4*), between 1950-63 increased demand for manpower in the US was confined to people with over twelve years’ education.
European countries some 10 per cent.\textsuperscript{108} Compared to the average for Europe in the thirties, four to five times more young people graduate from universities and, colleges today and the trend is continuing with unexpected rapidity. The Soviet Union plans to increase university admissions to 35 per cent of the age group by 1980.\textsuperscript{109} In the USA, the 1960-70 decade will double the numbers of university and college students, causing a further shift beyond 40 per cent of the age group.\textsuperscript{110} In Britain, student numbers will be multiplied 3.5 times over 15 years.\textsuperscript{111} At this rate we may expect that at the turn of the century the most advanced countries will reach a new frontier and cross it — half their young generation will have higher education — so long as these trends are not blocked by barriers set by society.

So far as we can judge from the inner logic of the scientific and technological revolution, as revealed by analyses of the empirical tendencies and synthesis of the model elements detected (changes in the relative position of physical and mental work, spread of creative activity, etc.), the future need will be for an educational base involving

a) \textit{full secondary education} for all — “polytechnical,” combined with a balanced education in the humanities, and founded on a scientific approach;\textsuperscript{112}

b) Wide-scale advance in elementary \textit{scientific, university-level} training — of such scope that no opportunity for cultivating

\textsuperscript{108} World Survey of Education, IV Higher Education, 1966; West Germany shows a marked lag in this regard.

\textsuperscript{109} \textit{Program of the Communist Party of the Soviet Union}, 1961. The sharp advance of Soviet higher education has aroused lively interest and had a considerable effect on educational programs in other countries. As C. P. Snow put it, “... the Russians have judged the situation sensibly. They have a deeper insight into the scientific revolution than we have...” (\textit{The Two Cultures and a Second Look}, New York-Toronto 1963, p. 39).

\textsuperscript{110} See \textit{Ressources en personnel scientifique et technique dans le pays de l'OCDE}, Paris 1961; \textit{Digest of Educational Statistics}, Washington 1965. American data include about 10 per cent of junior college students, which we have deducted in our figures—but this does not change the picture substantially.

\textsuperscript{111} \textit{Higher Education Report} (Lord Robbins), London 1963.

\textsuperscript{112} The idea of “polytechnical education” derives from Marx's broad concept of technology, which “reveals man's dealings with nature, discloses the direct productive activities of his life, thus throwing light upon social relations and the resultant mental conceptions.” (\textit{Capital}, I. p. 393 n.). Projects of polytechnical education in the Soviet Union and the socialist countries put the school on a scientific basis of production linked with a planned approach to activity, practical training and a broadly-conceived liberal education. Lenin was among the first to point out that there should be no question of “craftmongering” (\textit{On Polytechnical Education}, 1920). Under the pressure of industrialisation, the idea of polytechnical education was unfortunately quite often narrowed down to manual training in production.
the questing spirit will be lost and such potentialities will be constrained by nothing else than human abilities themselves.

Her economic structure has traditionally ranked Czechoslovakia among the countries requiring large numbers of educated personnel. It was no coincidence that in the twenties and thirties she recorded a higher ratio of university students to the population than all other European countries (except Austria),\textsuperscript{113} including France, Sweden, Germany (see Table 2-12). During the sixties, Czechoslovakia can record a gradual compensation of the postwar shortage of educated personnel.\textsuperscript{114} As things stand today, 36 per cent of general-school-leavers pass on to secondary education,\textsuperscript{115} a figure still below the level of many advanced countries. The labor force now includes 13 per cent of people with secondary-school training and by 1970 the figure should be 16 per cent; this in general meets the demand of the economy at the present stage. Some ten per cent of the relevant age group enter the universities, which is the average figure for advanced countries. University-trained personnel number three per cent of the labor force and by 1970 will reach 4.4 per cent; here Czechoslovakia is behind the USSR and Britain (where 4.5 per cent have university training), and, of course, far behind the US figure of 9 per cent of the active population; she is at about the same level as France and West Germany. Demand for university graduates is now met to about 90 per cent.

Naturally, we cannot confine ourselves to the situation as it has evolved so far. If we really envisage radical changes in the structure of work being induced by the scientific and technological revolution, we are faced with a serious choice of alternatives in the field of educational advance:

a) The next five to ten years may be expected to reveal an urgent need for improvements in general education. Today, we are already aware of serious gaps in the teaching of economics; neither the methodological grounding nor liberal educa-

\textsuperscript{113} According to figures collected by C. Clarke (\textit{The Conditions of Economic Progress}, London 1951, pp. 480-1), in 1925 university students per thousand of the population numbered 2.04 in Czechoslovakia, 1.45 in Sweden, 1.44 in France, 1.42 in Germany; the figures for 1930 were Czechoslovakia 2.33, Germany 1.98, France 1.88, Sweden 1.84.

\textsuperscript{114} The shortage was caused by the war-time gap, when the Germans closed down the Czech universities, and by the slow progress made in education during the fifties, when everything was concentrated on industrialisation.

tion provided can satisfy modern requirements. Unquestionably, secondary education for all will become indispensable within the next fifteen to twenty years.

b) The outlook for university education presents a wide range of possibilities. Should present trends continue, university graduates will number 6.4 per cent of the active population by 1980. But we have to bear in mind the prospect that the structure of the economy may have undergone profound change by that time. Czechoslovakia, as a country with fairly modest resources of raw materials and manpower, may be inclining more decidedly to the sophisticated work that conforms to her traditions and would mean that she had found her appropriate approach to the scientific and technological revolution. In this event, the country would need between 1980-5 to be able to rely on nine or more per cent of her active population being university trained — this would involve an intake of at least 20 per cent of the relevant age group, and the existing capacity of the universities would prove inadequate.

Every country reaching industrial maturity has to expect that the standing of its educational system in the national economy will acquire new and unaccustomed implications, which inevitably involves reconsidering some of the accepted proportions of resource allocation. Compared with the start of the century, the advanced countries now devote about threefold shares of their national incomes to education;\textsuperscript{116} in absolute terms, expenditure grew between 1950 and 1960, 5.8 times in France, 3.4 times in West Germany and Sweden, 2.8 times in the USA.\textsuperscript{117} While in the days of industrial development it seemed irrelevant as far as the economy was concerned to extend general education beyond the level of literacy, this distinction is seen to be out of

\textsuperscript{116} In terms of comparable national income, education received at the start of the sixties 9 per cent in the US, 7-8 per cent in the USSR and GDR, 6 per cent in Britain, around 5 per cent in Czechoslovakia, Poland and West Germany. The share of total investment expenditure going to education was 7 per cent in the USSR, 6 per cent in the USA, 5 per cent in Poland, 4 per cent in Sweden and Czechoslovakia—cf. H. Maier, H. Schilar, "Bildung als Ziel und Faktor des ökonomischen Wachstums in der sozialistischen Produktionsweise", Berlin 1967; J. Havelka, "Vyvoj a ekonomické postavení nevyrobní sfery" (Development and Economic Status of the Nonproductive Sphere, Prague 1966). These figures show quite clearly that—in relation to their economic level—the socialist countries devote much greater resources to education, in fact about as much as non-socialist countries with per head national incomes 50-100 per cent larger. Nevertheless, at this level even the substantial outlay on education in Czechoslovakia appears rather restricted, especially in respect of investment, the prime cause being deficiencies to be made up in the equipment of the universities.

\textsuperscript{117} According to data from F. Ebbing, quoted by O. Pavlik in "Škola ve svetle sučasnej vedeckej a technickej revolucie" (School in the Light of the Current Scientific and Technological Revolution), Pedagogika 2/1967.
place today: there is talk of "industrial education" as a powerful "growth sector" at an exceptional level of effectiveness and steadily growing, with an impact on economic growth surpassing that of the classical factors, and therefore calling for priority attention. But the matter goes deeper; in face of the new constellations of modern society — many only belatedly discovered — and of the enormous material power now within man's grasp, the level of education presently obtaining in many of the most advanced industrial countries of the West is seen to be inadequate; potential human resources are not being used. To accomplish the approaching cultural revolution and to release all its latent forces — therein lies the great opportunity for socialism, and this opportunity has to be seized if the initiative is to be taken in advancing the scientific and technological revolution.

Adapting the Educational System

Although the implications of changes in the level of schooling are undoubtedly far-reaching, the scientific and technological revolution makes perhaps still greater claims on the entire concept and system of education — claims posed by the new function of education in the life of the individual and society.

Under the industrial system shaped by the capitalist era, mass schooling was chiefly concerned with producing ready-made labor power. The educational system was therefore constructed as a closed system of limited content (the three R's), extended only for a restricted social stratum through the different types and grades of exclusive schools. But in this sphere, too, the impact of science and technology is evident. Pressure towards expanding and democratising secondary education is growing. In recent years there has been undisguised talent hunting in some sectors, employing modern methods of pedagogy and psychology. The


122 J. Vaizey notes in The Residual Factor and Economic Growth (Paris 1964) that there is an imbalance between "physical" and "human" capital in the West.
restricted selection imposed by class barriers is more and more felt as a drag and the response is seen in a measure of "democratised selection" to expand the "pool of capacity" required for competitive purposes. Here socialism has a big advantage with its genuinely democratic selection, providing an almost inexhaustible source of abilities. Nevertheless, the socialist countries face a problem of talent selection, though of a different kind. Their educational systems sometimes tend to train average ability, to lead a hundred per cent of their pupils to a successful conclusion. And this course, too, seriously conflicts with a true economy of human powers at a stage when the prime need is for quality, building up a potential — in fact, for quite informal searching for, refining and unfolding of talents and abilities at all levels. In this respect a universal and modern educational system acquires an independent role of its own, with no direct subordination to any claims of production. The issue is no longer what training for life can be instilled into people's heads or hands, but on the contrary what can be made of each individual, what unfettered creative forces of civilisation can be cultivated in him during his lifetime. One can hardly imagine such an undertaking being possible without a complete change in the concept of the pedagogical process and without equipping education with a solid sociological, anthropological, and especially psychological apparatus — either through separate advisory services, or through direct participation by the specialists in educational institutions.

As the scientific and technological revolution progresses, education takes on a dynamic quality, through its purpose, content, methods and finally its institutions. In the world of today the conditions are disappearing under which education could confine its aims to once-for-all preparation of labor power. The pupil of our times will have to spend his life adapting to changes in human knowledge, in work, the environment and the entire content of living. The wall separating education from life

124 In West Germany, France and Czechoslovakia, manual workers constitute the majority of the gainfully employed. But while in West Germany only 7-8 per cent of university and college students came from worker families and in France a bare 13 per cent (cf. J.-J. Servan-Schreiber, Le defi Americain, Paris 1967, p. 87), the figure for Czechoslovakia is 40 per cent.
125 When talent-seeking is the aim, student "drop-outs" are to be expected; the problem is rather one of using and regularising incomplete education.
126 O. Pavlik, Automatizacia a skola (Automation and the School), Bratislava 1959, p. 59.
127 "When once we have admitted that change has become a lasting phenomenon and that it is continually accelerating ... it is no longer possible that even the most complete education provided in childhood, in adolescence, or in the first years of adult life can prepare young people to solve all the problems which probably await them when they grow up ..." (A. S. M. Hely, "Nowelles tendences dans l'education des adults—quoted from Czech edition, 1967, p. 5).
is crumbling;¹²⁸ “learning for life” is giving way to lifelong education.¹²⁹ In contrast to the traditional operative, the modern technician needs to keep up with new developments all the time; in this age of explosive advance and rapid obsolescence in knowledge, he is compelled to learn throughout his life. By present estimates, without supplementary training, a technician loses touch with modern developments in his subject within ten years. After twenty-five years, half of what a scientist has learnt as a student is outdated. The traditional education fails even more disastrously when it comes up against deeper areas of emergent scientific synthesis, or entirely new concepts that for many people meeting with them in adult life remain completely incomprehensible. And since such developments are increasingly focussed on the very fundamentals of human life, and of social evolution, the onset of the scientific and technological revolution is manifested as a profound crisis in concepts and systems of education throughout the industrially developed world.¹³⁰

The prospect offered by the inner logic of the scientific and technological revolution tends towards abolishing the present division of life into a phase of acquiring knowledge and a subsequent lifelong stage of giving it out. Furthermore, education is ceasing to be a mere preparation, but is becoming an integral and substantial part of life. In many branches today it is already a permanent component of “working time”; for the future it may be expected to occupy a growing share alongside the actual “productive time”.

However, so long as lasting education is not an integral part of human work, the system of school education will have to

¹²⁸ Both Robert Owen and Marx stressed the idea of combining work and education—“not only as a means for increasing social production, but as the only way of producing fully developed human beings.” (Capital I, p. 522), which itself engenders a new productive force in society.

¹²⁹ P. Lengrad, “Adult Education”, Fundamental and Adult Education 3/1958, pp. 91-2. This idea has appeared in one form or another in earlier pedagogical theories, and in its developed form in the British “Final Report of the Adult Education Committee of the Ministry of Reconstruction” of 1919, in Soviet pedagogical projects of the early twenties (J. N. Medynsky, Entsiklopediya vneshkolnogo obrazovaniya, Moscow 1923) and in Thorndike’s Adult Learning, New York 1928. It was implicit in Comenius’ idea of “all life as a school” Vsevychova (Universal Education) Prague 1948, p. 214. But for centuries the idea was obscured by the empirical finding of the industrial age that under the given circumstances the only group generally susceptible to education were the young. Only when the dynamism of change had deprived once-for-all schooling of its basis could lifelong education become a practical proposition, and this is brought about by the onset of the scientific and technological revolution.

¹³⁰ Th. Litt describes the situation as a “victorious advance of things” and “impotence of education” (Technisches Denken und menschliche Bildung, Heidelberg 1957, p. 12).
be supplemented by a stage of further or post-graduate education, enterprise schools, "people's universities" and "academies", and use of the mass media — so that the vast diversity of educational media will gradually constitute a system of adult education.\footnote{L'\textit{education des adultes, tendences et realisations actuelles}, Paris 1950; again in \textit{Conferene mondiale sur l'\textit{education des adultes}}, Paris 1960.}

Assuming the above development, the very purpose of schooling will change, because it will ultimately have to conform to the concept of lifelong expansion of human powers. Here we are faced with a new and as yet unresolved question as to the \textit{optimal} regime for this type of education; the components will have to be distributed through the levels and types of school and out-of-school education in a manner best suited to the nature of contemporary knowledge of the world and how it can be transformed, while giving due weight to man's natural abilities at various stages of his life, in other words, starting from the requirements of man's self-realisation, with their specific rhythm and claims on education.\footnote{Man's perceptivity is related to the nature of his life. B. Suchodolski, for example, points out that understanding of the social sciences is on the one hand a necessary foundation for general education, on the other, however, it requires the experience of an adult ("Problemi upowszechchnienia nauki w epoce wspocz\acute{e}snej," \textit{Pedagogika dorostych}, ed. K. Wojciechowki, Warsaw 1962, pp. 276-282).}

None of the traditional \textit{concepts of education} has been capable of fulfilling these conditions. Anyone who pauses to consider the complex and mutable position of modern man in the world of his creations, with its shifting social relationships, will realise that it is no longer possible to make do with mere literacy supplemented by manual, craft training (the old type apprenticeship) providing no broad insight into the consistency of our civilisation. Even supposing that such training could suffice for a lifetime of working activity — that is, as labor power — which in itself is rather improbable today, it would certainly not be enough for man as a partaker in humanly ever more demanding transformations of society and civilisation. A society that stayed at this level in the future would inevitably pay the price in stagnation and internal conflicts\footnote{Adam Smith was not alone in regarding universal elementary education (intended to prevent people from "judging rashly or capriciously" without elementary knowledge) as a condition for achieving a lasting constitution, civil rights, democracy of the bourgeois type (\textit{The Wealth of Nations}, p. 343). By analogy we may say that a permanent system of lifelong education with appropriate universal schooling (probably at high school level) is a condition and guarantee of lasting development for a socialist society.} evoked by its inability to achieve mutual understanding and co-operation among its people.

Nor, in shaping a system of lifelong learning, shall we get far...
with the classical concept of secondary education\textsuperscript{134} which has its roots in the Ancient world, draws on the Renaissance concept of "the humanities" and found its shape in the grammar-school type of school. The weaknesses of the concept were already revealed by the industrial age. It was incapable of embracing the modern natural sciences, its profound sense of order was predominantly contemplative and therefore readily deteriorated into formalism, and its laudable endeavour to cultivate the subject culminated in the shallow demand for circumscribed encyclopaedic knowledge.

We can still observe today how as a reaction to the limitations of this classical concept emphasis is placed on "modern", practical, specialised teaching,\textsuperscript{135} primarily based on the concept of "objective natural science" that in the spirit of Descartes and positivism eliminated man's subjectivity, or with Bacon, and more precisely pragmatism, reduced it to the external relation of expediency. But the specialist with a narrow skill now finds great difficulty in adapting to the rapid succession of technological change if he lacks a background of systematic broad training, new methods and overall concepts are hard for him to grasp and altogether he is handicapped for life in modern civilisation.\textsuperscript{136} The "utility education" proposition actually repeats the illusions of the industrial system whose unfettered and spontaneous course is in fact a sum of well-considered and elaborated special acts; the educational concept therefore oscillates fruitlessly between the modern and grammar-school types, between external utility and inner order, spreading wider and wider the power of things and the impotence of education.

The world confronting us today is largely one of man's own creation\textsuperscript{137} that has assumed fateful dimensions for man himself.

\textsuperscript{134} A critique of past concepts of education has been made by H. Sychrova in \textit{Dlouhodobe zmény vzdelavacích systém a problémy nasi vzdelavací soustavy} (Long-term Changes in Educational Systems and Problems of Our Educational System), Study materials No. 2/1967.

\textsuperscript{135} In Czechoslovakia—as in some other European countries—this even results in an underestimation of general education as being "without practical value" (cf. J. Kotasek, V. Parizek, "Vedeckotechnicka revoluce v zvdelavaci system" (The Scientific and Technological Revolution and the Educational System, \textit{Sociologicky casopis} 2/1966). Compared with the secondary vocational schools, schools giving general education are rather limited and their shortcomings are an obstacle to discovering talented students for higher education.

\textsuperscript{136} In this connection J. B. Conant's critique of pragmatic concepts of education is instructive (\textit{The American High School Today}, 1960).

\textsuperscript{137} Indeed, Comenius (in \textit{The General Consultation on the Reform of Human Affairs}) already advanced as an argument in favor of universal education the fact that man had filled the world with his artificial inventions, thereby becoming a "competitor of the Creator"—of course, at that time only "in small measure".
Purposive mastery of his external creations is interwoven and conditioned by the unfolding of his inner potentialities. An education capable in these circumstances of fortifying creative activity would have to provide a far more effective methodological equipment than that of narrow specialisation, and a far deeper synthesis than that allowed by an encyclopaedic compilation of knowledge — it would have to give a broad scientific insight into the method of changing the world today and of man's self-creation, and come to terms with the present relationship between man and the technological world.\(^\text{138}\)

Education cannot keep pace with all new discoveries and theories in detail, but it can fulfil its mission in depth by enabling people to penetrate the fundamental dialectics of man and his handiwork in the civilisation of the times. The best system for this purpose would seem to be one providing a broad, general education — probably in the form of universal high school attendance — which would draw people by degrees into the most various areas of human activity. With potential talent being awakened and stimulated on all sides, there would be no danger of erecting a barrier of narrow specialisation that would condemn gifts discovered in later life to frustration, and conditions would exist for unfolding all abilities.\(^\text{139}\) Such a higher stage of integrated general education corresponds to the perspectives of modern science — to its new methods, its urge to coordinate different branches and its typical developments at the fringes of disciplines. And it is equally relevant to changing human activities at a time when tens and hundreds of professions and models of life are being swallowed up or recast by advancing technology and organisation. A well-founded general education gives a man greater mobility, flexibility, capacity to change, acquire new skills and embark on fresh training. A move in the same direction follows from the convergence of cultures in the world, the need to master the swelling stream of information, people's growing participation in social decision-making and — the strongest in the end — the claims of man's development for its own sake.

Yet hand in hand with the above it would be necessary to proceed from a solid basis of general education to a gradual and sensitive differentiation (choice of course, subjects, etc.) — and in the sense to individualise education — thereby cultivating

\(^{138}\) In his *Social Function of Science* (London 1939, p. 246) J. D. Bernal already called attention to the need for "humanising" science teaching.

\(^{139}\) In the British discussions on the future of automation the view has been voiced that only a fifth of the population is fitted for university education. But it would be advisable to examine this proportion—insofar as it accords with the facts—to see if it is not a product of the present system of general education.
all genuine bents in the young, before their gifts have time to grow superficial and be dissipated. Lacking a broad base, specialised education today fails to cultivate the whole man; on the other hand, without the required specialisation, man cannot make contact with the progress of civilisation.

Such a system of schooling can provide the best groundwork for adult education. But with its present forms adult education is in part just a substitute. Part-time study for employed people in the socialist countries is largely a way of making up for the injustices of economic discrimination and restricted access to higher education of capitalist days. Its value is declining, because the work load makes it difficult to guarantee the desired quality on a mass scale. But should leisure overstep a certain threshold, education while you work may evolve into a lasting symbiosis of working and learning. For the time being, factory schools and post-graduate university courses mainly serve a supplementary purpose, but with the growing interchange of scientific and technological knowledge, they will soon expand into an integrated system of permanent education involving a wide range of professional people as a matter of course.

Moreover, the mobile base of civilisation and human life endows adult education with a specific, unique mission. Not being tied to formal marks of attainment, its motives spring from deeper sources of modern life, revealing the need for human powers to unfold, the urge to engage in blazing new trails for civilisation, the longing to know oneself, the need to counter the uncertainty and instability born of overspecialisation and to satisfy the curiosity evoked by the onrush of time and passing of values, to establish a creative relationship to one's own self. However diffused and unstable these motives may be today, they represent the imminent product of technological civilisation, holding out the greatest promise for man's future. In time they will undoubtedly evolve their own institutional pattern.

As yet there is no knowing what agencies will take over such educational responsibilities or to what extent. Nor do we know how the flood of demands for teachers will be met. Generalisation of study will evidently lead in some degree to generalisation of teaching, which will also come to be a more or less universal human function alongside the functions of work and membership in the community that are commonly accepted today. One thing

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141 The possibilities of special sources in this connection have been explored by R. Maheu (cf. "Weltweite Bildungs—probleme in Zeitalter der Technologie", *Unsere Welt* 1985, ed. R. Jungk, H. Mundt, Munchen 1967, p. 204).
is certain — we shall reach a point when all the conventional means of education will be found wanting.

Technology and Education

Modern science and transformations in civilisation are perceptibly revising views on the content of the educational process. The consequences are felt in the teacher-pupil relationship, in teaching methods and techniques. Hand in hand with the emergence of the new content of education, the methods and techniques take shape, and only in this context can they really prove their worth.

Although the teacher will undoubtedly continue to be the leading figure, the next few decades will see a third factor, didactic technology, entering the educational process on a wide front.

Until recently the school remained almost untouched by technological progress. In the age of atomic and rocket technology, it plodded on with mass verbal instruction dating at least from the days of manufactories. While ten to twenty years ago attempts to individualise teaching on a mass scale met with insuperable obstacles because teachers were unable to cope with the varied rates of progress in big classes, we can now look forward to an effective individual approach through wide-scale use of the techniques that have been finding their way into education since the fifties.142

The discovery that learning is a process that can be controlled — like other types of behavior — by technically operated feedback of information provided the basis for programmed learning,143 either in Skinner’s original external (linear) programs, or the subsequent tendency among Soviet authors to use a more all-round algorithmic approach on a deterministic basis (Landa) or in the strategic learning on a stochastic basis used by Pask’s analytic school. Modern cybernetics could then be applied to pedagogy, and so the door was thrown wide open to management techniques, which in this case became techniques of learning.

A whole range of teaching techniques then emerges, with the most varied “teaching machines” capable of feeding back infor-

142 One of the founders of programmed learning, B. T. Skinner, believes that it was the endeavor to individualise, together with the growing structural shortage of teachers, that aroused interest in didactic technology (The World in 1984, ed. N. Calder, Baltimore, 1965, p.71).

143 D. Tollingerova, V. Knezu, V. Kulic, Programove uceni, Prague 1966.

mation, electronic language laboratories (audio-oral system), trainers and automatic testers, specialised class-rooms with technical equipment for handling and storing information, etc. Hand in hand with computer techniques, modern communications media come to the fore — closed-circuit radio and television, instructional films and transparencies, tape-recordings and especially video-tapes, earphone and optophonic apparatus, xerography, etc. The school of the future can be envisaged as using a multiple internal information system linked up with any external source (radio, television), which may play an important part especially at the higher levels. All in all, these techniques may be able step by step to relieve the teacher of monotonous routine, allowing him to choose from a range of teaching programs and to employ the most suitable information medium. He will be in a position to combine the frontal, differentiated and individual approaches to the best advantage. And he will be able to "call all the human senses into play" during the process of learning.145

The teaching media grouped around cybernetic nuclei will rapidly expand into an intricate technical complex, which in the end will probably find its universal inner linkages. But the teacher, who will continue to play the guiding role, cannot be expected to master the entire system of modern teaching technology; there will have to be a technical staff responsible for designing, setting up and maintaining the complicated mechanisms and apparatus. An idea of the magnitude of this change can be gained from the forecast that teaching technology will prove to be one of the biggest investment projects in the last third of the century.146 Despite its expensiveness, technologically-based teaching is remarkably effective, not only because without it schooling would have to be extended to 15 or 20 years, but also because it can be turned into an instrument for cutting the costs of instruction.147

145 Education for the Age of Science, Washington 1959, p. 17.
147 According to the calculations by the above-quoted Californian experts, published in the appendix to the Technology and the American Economy report, one hour of programmed instruction using the latest computers costs not quite 10 dollars, in three to five years the cost will drop to under one dollar, while ordinary verbal instruction by a teacher costs about two dollars an hour. The authors consider that to instal equipment linking up all class-rooms in the USA (some 1,000,000) to a computer network will in the foreseeable future be an economic proposition without any danger of absorbing too large a share of the national income.
The old familiar school with no other equipment than blackboard and chalk is out of tune with the times in another respect, too — it is unfitted to the mentality of young people aware of the prospects offered by modern science; and it undermines the authority of education altogether. For people surrounded from childhood by the products of modern technology, blazing new trails for civilisation will be an immanent need and lasting education intrinsic to their way of life.

The revolution brought by communications and teaching techniques into the school will, however, probably be overshadowed by the impact on adult education. The forms tried hitherto — works and local clubs, cultural centres, educational centres and the like, with the emphasis on lectures\(^{148}\) — are out of date and lack the appeal capable of inspiring people to cultivate their abilities. They can seldom compete with such "time-killers" as, for instance, the public house or bar. Modern communications and teaching techniques, linked with the schools, could turn adult education into a far more successful pioneer in the field of science, technology and the arts\(^{149}\).

Radio, the press, and most important, television and the videotape-recorder, look like being the media capable of freeing adult education from the four walls of the classroom and transposing much of the activity to the home, or workplace. Some countries (the USA, Japan) already have permanent educational channels,\(^{150}\) with complete university courses by television in some subjects; others (USSR) are rapidly adopting such methods. Television is obviously destined to hold the field in adult education, with a system of popular academies as its auxiliary. It would acquire even greater significance if its range were to be extended by videotape recorders in the home — which could have a revolutionary effect in this connection — and by organising the direct supply of reference material through modern media to individuals. Cybernetic techniques hold out even better prospects for the future; they could make learning equipment a feature of adult

\(^{148}\) Few institutions for out-of-school education are equipped for more than verbal instruction. In Czechoslovakia, where they are numerous, one-third lack a gramophone, two-fifths a tape recorder and one-fifth an epidiascope. Film projectors are more common, but usually they are old types.

\(^{149}\) A survey made by Illinois University of the extent to which the mass media are used in education throughout the world has shown a great potential of unused opportunities. (Mass Communications and Popular Conceptions of Education: A Cross-Cultural Study, G. Gerbner, Urbana 1964).

\(^{150}\) According to UNESCO reports, in the mid-sixties there were about a hundred TV educational programs in the USA, and around a thousand closed-circuit stations in schools. The Stanford University research anticipates that by 1971 all larger schools will be equipped to impart a third of all teaching matter to pupils in this manner.
education on a mass scale. The key would be the operation of large computers, each accessible to some thousands of users simultaneously by means of instruments in the home — telephones or video-telephones, automatic recording and small domestic "printing presses". The linked-up network of computer centres would act as an "information bank" ready to supply sources of instruction on request.

All this implies the approach of a profound revolution in all fields of education capable of restructuring the entire foundation. A completely novel situation arises — modern technology is acquiring the ability to allow anyone at any time to comprehend whatever he may need about the current structure of the world and the basis of human existence.

From Education to Self-Education

The point where the role of the scientific and technological revolution as an impulse to the development of human abilities will merge with its capacity to provide an opportunity for man's self-realisation will be when each individual emerges in the interweaving objective processes of civilisation as an active subject.

The rising generation, entering the educational process as the creator of potential reality, reaches out into the future; the world of today cannot satisfy it unless it finds satisfaction in what is actually already the past. The endeavor to identify the individual completely with social reality and his awareness of it can bear no fruit in the civilisation of our day. Unity has to be sought not so much in external affinity as in the integrated oneness of the individual. It is not the job of modern education to equip the pupil with a ready-made system of knowledge, but to give him the grounding and the method needed for his lifelong self-creation — above all, for the time when his teacher will not be

151 Cf. A. Oettinger, A Vision of Technology and Education, (Harvard program paper, reprint n.l). A project exists for a similar tie-up of 10,000 households to a computer centre in Columbia City.

152 Although the report of the National Commission for Technology, Automation and Economic Progress (Technology and the American Economy) is not favorably inclined to any views underlining the revolutionary nature of current changes in civilisation, wherever in its appendices it lets the education-alists be heard, we find the consensus of opinion to be that coming developments in education "spell a revolution" (D. D. Bushnell and co-authors, p. IV-27), the entire institution of education is "moving into the general scientific-technological revolution" (J. D. Finn, p. IV-33).

153 "In the past people could be educated by dealing with situations that their teachers knew, but now it has been recognised that the world that students enter will be widely, sometimes unpredictably, different from that in which they acquire their knowledge" (J. D. Bernal, "The Future, the Fundamental Factor of Scientific Education", article in Czech in Veda a zivot, 4/1963).
there to prompt him. The school of the future will have to turn the object of education into the subject of his own education, the being undergoing education into the being educating himself — education into self-education.\footnote{154} This radical change in man's attitude to his own self, which holds out the prospect of lifelong self-creation, presents the educational system with its most intricate problem for the coming decades of scientific and technological revolution;\footnote{155} its handling will provide the crucial test for the socialist course.

If man, having attained all-round development of his powers, is to be the creator of the objective conditions of his life, self-education is his true path to realisation and one of the fundamental modes of human existence in this day and age. The broader his approach to his world, the greater will be his ability to realise himself as a human being, that is to develop himself. And all-round development can no longer — or at least to an ever smaller degree — be achieved by imparting a body of knowledge about everything existing in the world; it can, however, be promoted by making knowledge accessible to a man who is capable of mastering it through his own activity, who adopts a creative relationship both to the object and activity, and to his own self. With the progress of technological civilisation it will no longer be possible to regard education as the attainment of a certain type of specialised qualification; the purpose will be to give people the groundwork for choosing their own specialisations. The aim of education will be to cultivate not a given type of person, but one able to shape himself to one type or another and to change from one to another.

Indubitably, this makes substantially greater claims on education.\footnote{156} Research on the frontiers of the human intellect usually indicates that abilities can be expanded indefinitely, but not factual knowledge. We have already reached a point when the sum of knowledge about the world cannot be encompassed even in its fundamentals; education based on acquiring pieces of knowledge will be an absurdity in the future. Moreover, the price of seeking encyclopaedic knowledge is paid in diminished capacity for logical thought. Nevertheless, a middle course exists

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\item[155] From this standpoint criticism is growing of concepts—including Skinner's—that reduce learning to outer-controlled reinforcement and demand its transference to an inner level (e.g. J. S. Brunner, \textit{On Knowing, Essays for the Left Hand}, Cambridge 1962).
\item[156] “Our changing civilisation will demand in the future an even greater devotion to learning and a greater pride in intellectual achievement” (\textit{Education for the Age of Science}, Washington 1959, p. 30).
\end{footnotes}
whereby imparting knowledge goes hand in hand with cultivation of the ability to retain and use information, so that fresh information can be acquired and deeper comprehension gained throughout a lifetime. This course directs teaching to imparting the *structure of a subject*, involving the transfer of skills to ever new spheres, and generalising the creative abilities.

The theory and practice of education have not yet come to terms with the sharp turns imposed by modern civilisation on the process of scientific cognition. For the most part they fail to advance beyond the dividing line between the picturable concepts of classical theories and the purely rational concepts and systems of modern science. They move in a world where the all-inclusive creation of a new nature by man that leads directly to man's own self-creation is not a factor of any substantial weight. As presented hitherto, objects and institutions either remain within the bounds of qualities perceived by the senses, or are explicable by direct reproduction of the mechanical design embodied within them — in any case, demonstration by means of analysis and synthesis. But such a world is no longer a faithful picture of our times. A method of education based upon it can no longer afford an insight into the inner dialectic of current processes of civilisation. In penetrating the reality of our day we discover on all sides areas of scientific findings that have to be grasped directly in their rationality, and cannot be exactly matched by any graphic, purely objective models. Cultivation of abstract thinking attuned to this level of reality, comprehension of logical systems, systems approaches and methods that take the dialectics of the object and the subject into account, these are emerging as the issue for truly modern education throughout the world.

In communicating the successes of modern science, which as fruits of human genius cannot be directly imitated, education can but proceed from a consolidated foundation of knowledge about the world, for perceiving which we are biophysically adapted, and from this range of knowledge ascend to the power of abstraction — in other words, retrace the adventurous path of getting to know (and transforming) the road trodden by mankind. Where this concentrated recapitulation up to the point of current human praxis is lacking, any preoccupation with learning some specific scientific finding, however up to date, merely serves the speedy obsolescence of this arsenal of facts that, together with the head in which they repose, are soon good for nothing.

If science is destined to be the leading force in the process of civilisation, *education* assumes the key position for the

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present. The scientific and technological revolution will be accomplished by people who are now leaving school, or will leave in the next few years, and they bear with them the potentialities and the limitations given by the education system of today. On their preparedness, their creative abilities, the mental dynamism manifested throughout their lives, will hang the fate of this civilisation to a degree unknown in any previous epoch. We may safely say that the society with the best scientific, educational and cultural system will in future occupy the position in the world once held by the country with the greatest natural wealth, and later with the mightiest industrial potential.