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KEYNES LECTURE IN ECONOMICS

Economic Performance and Education: The Nature of Britain's Deficiencies

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> If you have great talents, industry will improve them: if you have but moderate abilities, industry will supply their deficiency.
> Sir Joshua Reynolds, *Discourse to Students of the Royal Academy, 1769*

ONCE UPON A TIME it was considered not unreasonable to set the whole ambit of human knowledge as a proper target for an aspiring scholar; those days ended, it is often said, with the French *Encyclopédistes* of the eighteenth century. It now goes unquestioned that specialisation is required even during secondary schooling if the frontiers of knowledge are to be reached by a student in his chosen subject, and if he is to do so at a sufficiently early age to have the originality and energy to push those frontiers forward for the benefit of society as a whole.

But from which age should specialisation begin, and to what extent? That kind of question in relation to academic specialists will not be unfamiliar to those here. The more difficult and, I suggest, economically more important question relates to the great majority who are not to become specialist scholars: what is the appropriate mix of general and specialised studies, including occupationally-relevant subjects, that should occupy the time of *most* young persons during compulsory

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schooling, and in the immediately subsequent years during which they prepare for a career and for vocationally relevant qualifications?

These matters have acquired great public prominence in this country in the past decade as disappointment has grown with the performance of the economy, and dissatisfaction with related fundamental elements of the country's schooling and training systems. It led to highly important legislative intervention by central government — associated with the Education Reform Act of 1988 — in the form of a National Curriculum for schools, nationwide tests of the attainment of pupils in state-maintained schools (at four prescribed ages between 7 and 16) and a new system of National Vocational Qualifications. Much of the implementation of these initiatives is still — to put it kindly — in the trial-and-error phase; it still remains difficult to find adequate analytic thinking on the underlying issues of principle commensurate with the importance of these issues for the nation's welfare.

In the hope of stimulating others to contribute to these matters, I propose to describe in this lecture (what, as it appears to me, are) certain highly important current differences in education, training and industrial productivity between Britain and other advanced industrial countries — mainly our immediate European Continental neighbours. Much of what I am able to say derives from a series of research visits to matched samples of manufacturing plants, vocational training colleges and schools in Britain and on the Continent, carried out in the past decade by small teams from the National Institute of Economic and Social Research; these teams were aided by school inspectors, school teachers and industrial training managers from this country, and researchers from corresponding institutes abroad.[1] I shall also draw on the now extensive series of international comparisons of the schooling attainments of large samples of pupils carried out since 1964 by international associations of educationists, the results of which need to be more widely known in this country. By considering how other countries have in practice settled, for example, on the balance between academic and vocational education, and between theoretical and practical aspects within subjects of study, perhaps a better consensus can be reached here on the appropriate next steps, both in public policy and in related social research.

[1] Details of most of the earlier NIESR studies in this field will readily be found in the compendium of reprints entitled *Productivity, Education and Training* issued by the Institute in 1990 (2nd impression); to save tedium and space, explicit references are given in footnotes to this lecture only to subsequent studies.

Academic and Practical Education: Definitely not a New Issue

The emphasis in British education on academic rather than practical attainments is a long-rehearsed theme of writers on social and economic affairs. Two hundred years ago Adam Smith complained that 'the greater part of what is taught in schools and universities does not seem to be the most proper preparation' for that which 'is to employ them during the remainder of their days'.[2] He attributed this deficiency to a lack of immediacy in the connection between the concerns of teachers, paid out of the public purse, and the needs of employers and their potential employees. A substantially greater orientation of Continental schooling towards the requirements of working life was increasingly noted in Britain as the nineteenth century progressed, leading to a series of Parliamentary Inquiry Commissions (the 'Taunton' Schools Inquiry Commission, 1868; the Devonshire Commission, 1872; the 'Samuelson' Commission, 1882–4; the 'Bryce' Commission, 1895); these drew attention in particular to Germany's rapid industrial development, and to the need for Britain to emulate Continental approaches to education. 'Our evidence appears to show that our industrial classes have not even that basis of sound general education on which alone technical instruction can rest', said the Taunton Commission in 1868. 'Even if such schools [for technical instruction] were generally established among us, there is reason to fear that they would fail to produce any valuable results for want . . . of sound elementary knowledge of the learners.' The urgent need, as they saw it, was for schools which gave teachers 'considerable freedom in the use of methods, but [defined] the chief aim and purpose clearly and precisely, and that aim should be thoroughly to satisfy the demands of the parents for good elementary teaching, and then, and only then, to add anything more.'[3] These themes, as we shall see, retain their relevance today.

Many important educational developments in schooling ensued, including funding for higher grade elementary schools, junior technical schools, provision for continuing education and the possibility of compulsory day-release from work for two years after compulsory full-

[2] Adam Smith, *Wealth of Nations* (1778; Everyman ed., 1910), vol. 2, p. 257.

[3] (Taunton) Schools Inquiry Commission, vol. 1, *Report of the Commissioners* (1868), pp. 78–80.

time schooling (under the 1918 'Fisher' Education Act'[4]); but these developments were on a limited scale. In 1919 the great Cambridge economist Alfred Marshall published his remarkable study contrasting *Industry and Trade* in Britain with the United States, France and Germany; in discussing the foundations of industrial progress, he still felt it right to say — notwithstanding the terrible World War with Germany that had only just ended — that 'all the world has much to learn from German methods of education'.[5] He went on to suggest that in respect of education 'the same may perhaps be said of Scandinavia and Switzerland' as of Germany.[6] In early editions of his *Principles of Economics* (1890–8) he referred more broadly to the virtues of *Continental* systems of education: 'On the whole we may say that at present England is very much behind as regards the provision for the commercial as well as the technical education of the proprietors and principal managers of industrial works'; and the German system in particular has produced men 'who are better fitted to do the work required of the middle ranks of industry than any that the world has ever seen'. The English education system, he thought, was superior in developing 'daring energy and restless enterprise'. He approved of the steps then being taken in England to encourage very broad scientific and technical education in schools, but these 'are prevented from being turned to the best account by the still backward condition of our elementary schools'.[7] The above few words, I trust, are sufficient to remind ourselves that the problem that concerns us this evening has a considerable history.[8]

That other countries should follow the path pioneered by Britain's industrial revolution, and that Britain's lead in living standards should consequently diminish, was not of course surprising. Yet, as appeared from the late Dr Rostas's comparisons of the manufacturing censuses

[4] The experimental introduction of compulsory day-release in Rugby in 1920 is described in Appendix E of *Productivity and Industrial Structure*, by the present writer and colleagues at the Institute (Cambridge, 1981), pp. 294–5.

[5] A. Marshall, *Industry and Trade* (Macmillan, 1919; 4th ed., 1923), p. 130.

[6] Ibid. p. 131.

[7] Ninth (variorum) ed. of Alfred Marshall's *Principles of Economics* (ed. C. W. Guillebaud, Macmillan for the Royal Economic Society, 1961), vol. II, pp. 307–8.

[8] Correlli Barnet, *The Audit of War* (Macmillan, 1986) provides a full and very readable historical introduction to our subject; a shorter survey is available in the opening chapter of Professor D. H. Aldcroft's recent book, *Education, Training and Economic Performance 1944 to 1990* (Manchester UP, 1992); I have also benefited from Professor Margaret Gowing's lecture to the Royal Society on 'Science, technology and education: England in 1870', reprinted in *Oxf. Rev. Education* (1978), p. 3.

of Britain and Germany (carried out at the National Institute in the early 1940s), that 'catching up' process was slow: it was not until the 1930s that the average 'productivity of labour [became] approximately the same' in these two countries, when calculated over a broad cross-section of 20 manufacturing industries. At that time there was a 'German advantage in the capital goods industries such as iron and steel'; but, as far as industry as a whole was concerned, they were offsetting British advantages in consumer goods such as food manufacturing.[9] Only in the past generation or so has it become evident that the main Continental countries have overtaken Britain in industrial productivity as a whole, and in their living standards.

True, the United States had been ahead in these respects by the end of the nineteenth century; but that country's success could be attributed to special factors not transferrable to Britain — such as the greater initiative and inventiveness of an immigrant population, the greater readiness of consumers there to accept uniform mass-produced manufactures, and the great size of its market. It could also be said — by way of qualification to the available statistics on real incomes — that the greater variety of product-qualities available in Britain, and higher average qualities, were valuable advantages not brought into account in statistical calculations of output per head.

In the early 1950s systematic visits to samples of manufacturing plants in the United States were undertaken by some 70 Anglo-American Productivity Teams — each consisting of a score of industrialists, engineers and trade union representatives — to examine the sources of higher American productivity. The plants they visited tended to be untypically large, with over a thousand employees. Plants of that size accounted for only a third of all industrial employment in the US (the median plant size in American manufacturing at that time was only 390 employees, and the corresponding British median plant consisted of 470 employees).[10] The productivity teams brought back messages based on the benefits of product-standardisation, greater specialisation by individual plants in particular sections of each industry's product-range, long production runs, and — particularly important for our concerns — the extensive use of unskilled operatives to produce

[9] L. Rostas, *Comparative Productivity in British and American Industry* (Cambridge, 1948); comparisons with Germany are on pp. 35 and 40.

[10] The median plant is here defined such that half of all employees are in plants below that size, and half in plants above that size; statistics of plant sizes are summarised in *Productivity and Industrial Structure*, p. 27.

efficiently on long mechanised production lines, with each operative carrying out repetitive operations of severely limited span.[11] This last observation reinforced ideas that most young people did not need extensive specialised vocational education and training.

Comparisons of Productivity and Manpower-Qualifications in Matched Samples of Plants

Let me now move forward to the studies carried out in the past decade by the National Institute. As part of a broad investigation into current sources of international productivity differences, a series of matched samples of manufacturing plants in five industrial sectors were visited in Britain and the Continent. Plants of sizes that could be considered as fairly typical of each industry were chosen (based on the central half of total employment in each of the selected industries, when plants are ranked by size).[12] Given our limited research resources, only a dozen or so plants could be visited in each industry in each country; by limiting ourselves to much the same central size-range, it was hoped to obtain a more reliable view of differences between countries in the skills of the bulk of the workforce, and their consequences for productivity. Very large and very small plants (say, of over 1000 or under 20 employees) no doubt have additional differential characteristics which deserve study; but even such plants must be affected by the very large international differences in skills that were observed in the central range of plants visited.

The plants included in the National Institute's studies lay in the range of 30–250 employees in the clothing industry (an industry in which plants tend to be small), rising to 50–500 employees in the engineering industry (where plants are typically larger — though not to the extent popularly imagined). In furniture, they were between the ranges just mentioned; only in biscuits did the range stretch to over

[11] *Final Report of the Anglo-American Council on Productivity* (London, 1952). Note the warning that the plants visited 'were not necessarily representative of the whole of industry in the US', in the Council's report on the *Training of Supervisors* (1951), p. 4. For the substantive messages see, e.g. the reports on *Pressed Metal* (1950), p. 44, *Valves* (1951), pp. 48–9, and *Furniture* (1952), p. 63.

[12] More precisely: based on the size-distributions of plants by employment, as recorded in Censuses of Production or similar statistical sources, the initial choice was from plants that spanned the central half of the industry's total employment in each country; the range was then extended where necessary to provide an overlap in sizes between the countries.

1000 employees. The plants visited were thus, on the whole, considerably smaller than those visited by the Anglo-American teams. Particular sectors of each industry were selected to ensure that similar products were made by the plants visited in each country. For example, in engineering we selected plants making springs and drills within certain dimensions; in clothing, women's outerwear manufacturers were chosen; and in food manufacturing, we concentrated on biscuit manufacturers. Varying degrees of skill-intensity typify these industries, from the precision required in engineering (often to a thousandth of an inch); to woodwork (where tolerances may be a sixteenth of an inch) and to the predominantly less skilled workforce in biscuit plants, the majority of whom are now mainly engaged in packaging activities (the main production activities in biscuit plants are heavily mechanised and under the control of a relatively small number of process-workers). In addition to these manufacturing industries, a service sector — namely, hotels — was included; the object was to examine whether international productivity differences in such a service sector were — as often suggested by academic writers — substantially lower than in manufacturing; and whether, even so, vocational training in the relatively straightforward domestic tasks involved might significantly affect productivity.

In recent years Labour Force Surveys have been carried out in many countries asking large samples of households for the vocational qualifications of their members. Our site visits were intended to go beyond that, in that we compared the vocational qualifications of personnel in specific types of operations and the consequences for productivity. Let us however first consider the overall structure of workforce qualifications in a number of countries as derived from such household surveys. In very summary form, Table 1 here compares the vocational qualifications of economically-active persons in Britain with France, Germany, the Netherlands and Switzerland, distinguishing just four broad groups of vocationally-relevant qualifications. Estimation and approximation are unavoidable in putting the different ranges of qualifications in each country on to a common basis, but I believe that the main lessons to be drawn from this table can be relied upon. They can be summarised as follows.

1 *University qualifications* About a tenth of the workforce now has university degrees in these countries. Britain's 11 per cent is as high as the German and Swiss proportions in the whole economy and, higher than France's; in manufacturing, Britain now employs a slightly higher proportion of graduates than Germany. Any inadequacy in Britain's education thus does not lie in any simple way at the university first-degree level taken as a single total. The trend in Britain continues to rise very strongly: numbers of students in higher education have risen by an extraordinary 60 per cent in the four years 1987–91 (this relates to all full-time home students in their first year on first degrees at universities and polytechnics);[13] some 14 per cent of the relevant age-group in Britain now graduate with university degrees — if anything, slightly ahead of the proportions in Germany and Switzerland. Doubts are now sometimes voiced in this country as to whether that expansion has been overdone.[14]

If we look into subject-detail, we find more significant differences. Germany has some 50 per cent more home graduates in engineering and technology than has Britain (all expressed as proportions of the relevant age-groups at graduation), and somewhat more in other vocational subjects (law, business, etc.); while Britain has a greater proportion of graduates in languages, arts and even in *pure sciences*. The recent White Paper on science policy was also concerned that 'too few of the most able [students] are attracted into engineering careers'; and there are worries as to whether enough first-degree engineering graduates proceed to post-graduate courses and to doctorates, so as to be able to head development teams in our larger engineering firms.[15] It is necessary to emphasise that our worries should not be about increasing further the numbers graduating in *pure science* — in respect of which there continues to be much drum-beating — but specifically about graduates in engineering and applied technology.

[13] DfE, *Statistical Bulletin* 17/93.

[14] J. Murphy, 'A degree of waste: the economic benefits of educational expansion', *Oxf. Rev. Edn* (1993), p. 9.

[15] See the White Paper *Realising our Potential* (Cm. 2250, HMSO, 1993), p. 55; and a forthcoming report on post-graduates in engineering and technology by my colleagues Geoff Mason and Karin Wagner. Some 30,000 diplomas in engineering and technology were awarded to home students in Germany in 1990 (at universities and *Fachhochschulen*), compared with only 13,000 first degrees in Britain (at universities and polytechnics). Those who doubt the prospects of employment in Britain for more post-graduates in engineering need to consider the role of the Fraunhofer industrial research institutes in Germany. The proposal to set up Faraday Centres on similar lines in this country was not supported by the House of Lords Select Committee on Science and Technology (*Faraday Programme*, HL Paper 50, January 1993); but I suspect a closer investigation into the extent and routes that government subsidies to applied research can be administered under such an arrangement would lead to a more positive verdict.

Table 1. Vocational qualifications of the workforce in Britain, France, Germany, the Netherlands and Switzerland, selected years 1988–91.

	Percent of all economically active persons				
	Britain 1989	France 1988	Germany 1988	Netherlands 1989	Switzerland 1991
University degrees[a]	11	7	11	8	11
Intermediate vocational qualifications	25	40	63	57	66
Of which:					
Technician[b]	7	7	7	19	9
Craft[c]	18[d]	33	56	38	57
No vocational qualifications[e]	64	53	26	35	23
TOTAL	100	100	100	100	100

[a] For Britain, includes professional qualifications of degree standard. For Netherlands, includes HTS diplomas and university education of three years or more.
[b] For Britain, includes BTEC, HNC, HND; sub-degree qualifications in teaching and nursing. Corresponding qualifications in other countries (e.g. for France, DUT; for Germany, includes *Meister*).
[c] For Britain, includes basic qualifications excluded in other countries (see text), i.e. City and Guilds Part 1 and above; BTEC National and equivalent; apprenticeships (NVQ level 2 and above; see n. *d*). For France, CAP and BEP. For the Netherlands, MBO diplomas (apart from HTS) and half of all LBO diplomas (corresponding to those at levels C and D, and half of those at level B; see text). For Germany, *Berufsabschluss*. For Switzerland, includes also half of those completing lower level qualifications based on 1–2 years traineeship course (*Anlehre*).
[d] Of which approximately 9 per cent at City and Guilds Part 2 and equivalent (NVQ level 3) and 8 per cent at City and Guilds Part 1 and equivalent (NVQ level 2).
[e] Only general education (below university level). For Britain, includes those with GCSE or A-levels, but without vocational or university qualifications. For the Netherlands includes half of LBO diplomas (half of those at level B and all at level A), and those without LBO diplomas; for Switzerland, includes half of *Ahlehre* qualifications.

Sources: Estimates based on national Labour Force Surveys, including special tabulations prepared for NIESR; national qualifications reclassified to common basis as far as possible. For details on France, see the article by Steedman in *National Institute Economic Review* (August 1990); Netherlands, Mason *et al.*, ibid, (May 1992); Switzerland, H. Hollenstein, National Institute Discussion Paper no. 54 (September 1982), and work in progress by Bierhoff *et al.* at the Institute.

2 *Intermediate vocational qualifications* It is at the level of vocational qualifications — corresponding to our BTEC and City and Guilds certificates at various levels — that there is an enormous gap between Britain and the other countries considered here. Some two-thirds of the total workforce have qualified at these levels in Germany, the Netherlands and Switzerland, compared with about a quarter here. The French proportion lies somewhere between Britain and the other countries mentioned, but is rising fairly rapidly.[16]

Qualifications of this type have usually been attained 2–4 years after compulsory schooling — say, at ages 18–20 — on the basis of day-a-week attendance at college, while for the rest of the week the young person is engaged as a trainee or apprentice under the supervision of a master-craftsman; alternative full-time college routes of shorter duration leading to similar standards are also available. Germany and Switzerland continue to follow mostly the day-release route, and emphasise the benefits resulting from college-learning and shop-floor experience (with on-the-job training) proceeding in parallel; France and the Netherlands, on the other hand, rely more on full-time college routes, accepting that it may require a subsequent year or two of full-time work-experience — including structured broad on-the-job training — to attain full proficiency.

Extensive final examinations of a written and practical kind are characteristic of these Continental systems of vocational qualification: these examinations are externally set, and are externally marked by examiners who do not know the candidate. Much emphasis is placed on the need for objectivity and marketability of such qualifications. Specimen test papers for selected major occupations provided the basis for our identification of equivalent levels of attainment in those countries and in Britain. Later in this lecture we shall need to refer (I fear, critically) to recent changes in Britain's examination procedures for vocational qualifications. At this stage it is necessary only to note that the level hitherto usually represented by our City and Guilds examinations (at part 2) corresponds to the main craft-level of qualification recognised on the Continent. It is this level that has been adopted as the guiding minimum criterion in attempting to put together in Table 1 internationally comparable estimates of the proportions of the workforce with vocational qualifications. For Britain — in order

[16] H. Steedman, 'Improvements in workforce qualifications: Britain and France', National Institute Economic Review (August 1990).

not to be unduly severe on locally accepted usages — we have nevertheless also included a proportion of those completing time-served apprenticeships (though, since these do not always involve external examinations, they would not necessarily be recognised on Continental criteria of a qualified craftsman).[17]

Vocational qualifications in all these countries can be sub-divided into a technician/supervisory level and a craft level — a distinction that is helpful in locating a little more closely the nature of Britain's training deficiencies. The former level can broadly be said — in the context of manufacturing industry — to be for those engaged on process and methods planning, or on design and development, or on work involving substantial supervisory elements; the craft level is for those mainly engaged in carrying out skilled work, often to specifications produced by technicians and professional engineers. Prior general educational requirements are usually higher for entry to technician than to craft courses (say, middle grades in four subjects at O-level for technician courses, compared with CSE grades 2–3 in four subjects for craft courses — or their equivalents in GCSE).

Our estimates of the proportion of the workforce with technician qualifications in Table 1 indicate that Britain is fairly close to most other countries, with some 7 per cent of the workforce at this level (only the Netherlands appears out of line, with very many more qualifying from their higher vocational colleges — their HBO — in some ways compensating for their lower proportions qualifying at graduate and craft levels). The distinctive feature of Britain's workforce is thus substantially concentrated at the craft-level of vocational qualification; broadly speaking, a further 30 per cent of the workforce would have to attain this level for Britain to be comparable to the other countries listed in this table.

The lack of adequate numbers of craftsmen in Britain has wider consequences; for example, graduate engineers in British firms far too often undertake work that would elsewhere be undertaken by qualified

[17] The present estimates of the proportions qualifying in Britain at intermediate vocational levels (City and Guilds and BTEC examinations) are slightly lower than given in our previous papers, and have benefited from the recent work of the Department of Employment (Training Division, Sheffield; see Annex 4 of the article by P. Helm and D. Redding, 'The national education and training targets — methods for monitoring the targets', *Employment Gazette* (July 1992), 346). The estimates are approximate, but the uncertainty is not such as to raise doubts on the substantive conclusions drawn above.

craftsmen. This transfer, it must be suspected, contributes to the lower rewards that graduate engineers command in this country.[18]

3 *No vocational qualifications* In consequence of the foregoing, a greater proportion of the workforce in Britain is shown by these surveys as not having attained any *vocational* qualification of substance. This is not to say that such persons are all necessarily without *general* educational qualifications, such as GCSE or A-levels. The point rather is that the notion of a clearly defined qualification in a *métier* or *Beruf* — to be acquired subsequent to the completion of compulsory schooling by training, further study, and rigorous testing — is not as accepted a part of the spectrum of educational ideals in Britain as on the Continent; the figures in this table provide a quantitative indication of the extent of that discrepancy.

I suspect many will find that the figures in Table 1 support their existing prejudices. Switzerland's workforce appears on these figures as slightly more highly qualified vocationally than Germany's; both these countries are slightly ahead of the Netherlands — the latter country having fewer university graduates but more technicians; France is striving to reach those countries' standards, but has some way to go; Britain has to go much further — but *not* at the top educational levels.

The consequences of these differences in skills were manifest in very many ways on our visits to our matched samples of plants, both in the quantity of output produced per employee and in its quality (fitness for the detailed purposes of each customer, controlled delivery on time, tight tolerances). The following few examples may be sufficient to convey the flavour of our observations; but they have to be regarded as only the visible tip of an iceberg which must have many other aspects than we were able to observe. Breakdowns of machinery were noticeably more frequent in British plants with, say, a machine on a major production line out of action at the time of our visit in half the British plants visited, whereas a breakdown of that sort was very much less common on visits abroad.[19]

The main machinery observed in the British and matched Continental plants was often very similar, and often even of identical make;

[18] H. Steedman, G. Mason and K. Wagner, 'Intermediate skills in the workplace: deployment, standards and supply in Britain, France and Germany', *NIER* (May 1991).

[19] About a third as frequent, on the basis of the food-manufacturing sample (about 10 per cent of planned machine working-time lost in Britain due to emergency downtime, compared with 3–4 per cent on the Continent).

but there were clear differences in maintenance standards. Routine preventative maintenance was normal on the Continent, and was carried out by vocationally-qualified staff — some qualified at craft level, others at technician level. In Britain, maintenance teams were more often engaged on 'fire-fighting' repair work, leaving little time for routine maintenance. Members of British maintenance teams were often time-served craftsmen (i.e. without externally examined qualifications) assisted by unqualified 'mates'. Inter-country differences of this kind were evident in all the manufacturing sectors that were compared. They are consistent with the widely heard view that when machinery in Britain works, it works as rapidly as in other countries; the trouble is that it does not always work — as users of London Underground's lifts and escalators well know. In other words, a shortage of maintenance skills affects the efficiency not only of manufacturing industry, but also of the great variety of other sectors of the economy that rely directly or indirectly on such skills. Machinery breakdowns seem to have become the accepted part and parcel of our everyday life.

So far on maintenance skills. Turning to those engaged on more straightforward operative tasks: many in Continental plants were without vocational qualifications. Nevertheless, a greater proportion were qualified than in Britain, the proportion depending on the degree of skill required in that trade or occupation. For example, on the Continent *few* biscuit packers, *some* metal-press operators and *most* sewing machinists were vocationally qualified — whereas in Britain hardly any were qualified in these occupations even at a basic level. The benefits of operative training were apparent in various ways. For example, it was normal practice on the Continent for metal-working operatives to clean their own machines as necessary, rather than be required — as in Britain — to leave this task (because of the risks involved and the need for care) to be carried out by maintenance staff at the end of each week; the consequent lower levels of swarf contributed to less wear on tools and fewer breakdowns. Further, because of their better training, Continental operatives became aware at an earlier stage of any malfunctioning of their machinery; adjustments could be carried out at a convenient moment, before serious interruption of work and before damage to work in progress, to the machine or its tooling.

The ability of a better trained operative to carry out a greater variety of tasks was another benefit of systematic training, leading to lower reserve manning-levels. More important, the ability to adapt rapidly to changing job-specifications permitted the efficient production of specialised shorter runs of higher market value to meet individual customers' varied needs. The clothing industry provided a remarkably clear illustration. In the German clothing plants visited, the great majority of sewing-machine operatives had undertaken 2–3 year training courses, and had passed vocational examinations comparable to our City and Guilds (at part 2). In the matched sample of plants visited in Britain, examinations at that level had hardly ever been taken by operatives — only by supervisors. The British plants concentrated on producing long runs — say, 100,000 pieces — of standard patterns of blouses or skirts; the German plants typically produced very many short runs — say, 300 pieces — of more complex and more expensive styles (for example: using patterned material which needed careful matching at seams, more darts and tucks to give three-dimensional shape, and more decorative stitching). The industries of both countries had roughly the same total employment, and exported roughly the same number of garments; but the unit value of the average German garment exported was double that of the average British garment — reflecting (not unfairly, to our eyes) the greater degree of workmanship, individuality and styling embodied in the German garment. Production based on shorter runs is obviously more costly, since it takes time and experience for an operative on a new style to avoid mistakes and reach full operating speed. It appeared from our enquiries that a German qualified operative on a new style would be able to reach efficient working speed in perhaps three *days*, and could do so by herself on the basis of a drawing or paper pattern; the English operative typically needed a demonstration by the supervisor, and took perhaps three *weeks* to reach efficient working speeds. The availability of workforce skills thus affects management decisions on the quality segment of each product market that can realistically be targeted, and ultimately affects the real incomes that can be earned in that industry.

Parallel contrasts in quality-specialisation were evident in the woodworking industry, where we compared producers of fitted kitchen cabinets in Britain and Germany. The German firms produced mainly for the high quality section of this market, in which they had established a high reputation, while the British firms produced mainly for the cheaper do-it-yourself section. Differences in the observed skill composition of the workforces were clearly relevant in the respective countries' product strategies, much in the way just described for clothing manufacturing.

In food manufacturing, our analysis of quality-differences was taken a step further by, so to speak, pointing a microscope at an apparently very simple product — biscuits. Average tonnage produced per employee, the crude indicator of productivity used in statistical comparisons of this type, was — surprisingly — fifth *lower* in the German plants visited than in the British plants; but, as became evident on our factory visits, there were substantial differences in quality-mix. German plants produced a greater proportion of more complex, varied and expensive biscuits (coated, multi-layered, multi-wrapped and cartoned), while British plants produced a greater proportion of simple products (plain single-layer biscuits, wrapped in a single plastic foil). As a first approximation to putting a monetary value on such differences, the output of each country's sampled plants was allocated to three broadly defined quality ranges on the basis of their physical characteristics; relative unit values were then attached to each range based on estimated ex-factory prices in order to derive an indicator of the real *average* value added per kg.[20] On this basis the average quality of the German product was estimated to be some 75 per cent above that in Britain. A 'quality-adjusted' measure of productivity (combining the lower physical output per employee with the higher value added per physical unit) put German average productivity at about 40 per cent above Britain in this industry.

Similar comparisons for this industry were carried out in France and the Netherlands. In both these countries a higher average quality of product was evident — not as high as Germany's, but some 10–15 per cent above Britain's. Differences amongst these four countries (i.e. Britain, France, Germany and the Netherlands) in average quality of this product made as important a contribution to value added per employee as did differences in average tonnage produced per employee.

Speaking more generally, it seems more than possible that competition amongst industrially advanced countries has increasingly led to a degree of international quality specialisation in manufactured products — with higher income and higher skilled countries tending to produce high quality varieties, and lower income and lower skilled countries tending to produce a greater share of standard varieties. Issues associated with the measurement and implications of such inter-

[20] Adjusted for ingredient costs and estimated retail margins in each country — but these did not substantially affect the result quoted summarily above (for details see the article by G. Mason *et al.* in the *NIER*, forthcoming).

national differences in product quality, are likely to warrant considerable further research efforts.

There is space here to do no more than mention the results of our comparisons of productivity in hotels. Based on employee hours per guest night in hotels of comparable grading (using Michelin grades), these comparisons showed German and Dutch hotels to be over 50 per cent more efficient than British hotels; the intensive and broad systems of Continental training at supervisory levels (e.g. housekeeper, receptionist) seemed to be the main factor contributing to their better utilisation of resources.

Returning to our main theme: there is a clear contrast between the Institute's recent observations of important productivity benefits deriving from a workforce predominantly trained to craft standards on the Continental pattern, and the observations by the Anglo-American Productivity Teams some 30–40 years ago of the benefits of mass production systems manned by a largely untrained workforce, each carrying out simple repetitive operations. Part of that contrast may be illusory in that, as already suggested, the Anglo-American Productivity Teams gave undue weight to their observations on exceptionally large plants, not representative of the bulk of industry; but perhaps the more important part of that contrast derives from the advance of mechanisation and, subsequently, of automation. These two aspects of technical progress — mechanisation and automation — might seem closely related, with automation being just a later and more advanced form of mechanisation; but their effects on industry's demand for unskilled labour are very different, and deserve a word of explanation if we are to appreciate fully the nature of our current employment difficulties.

The process of *mechanisation*, as ultimately exemplified in what is now often called 'Fordism' or 'Taylorism', consisted in the replacement of skilled craftsmen by machines and by conveyor belt assembly lines operated largely by unskilled or semi-skilled labour. As a result of mechanisation the demand for unskilled persons rose, as did their earnings. In the more recent phase of *automation*, of importance since (say) the 1960s, the work of very large numbers of unskilled operators of machines is replaced by automatic devices — for example, for feeding, activating, transferring to other machines or tools, and unloading the processed workpiece. The advance of automation continues steadily, and affects office work of many sorts as well as the type of direct production just mentioned. The result has been a fall in demand for unskilled labour, especially of inexperienced and technically unqualified youngsters; that fall in demand must be expected to continue as automation is applied in one process after another. With that fall in demand, we must expect increased unemployment among the unskilled, and a fall in wages offered to them. It is that contrasting effect of technological progress in recent decades that has caused confusion in assessing prospects in the labour market: an initial rise in the demand for unskilled labour due to mechanisation, accompanied by a rise in the relative wages of the unskilled — followed by a fall in the demand for unskilled labour due to automation and a fall in their relative wages. For the sake of clarity, I have set this out in simplified terms, though it would be more correct to speak in terms of predominating tendencies — rather than distinct phases — of these aspects of technological progress.

As is well known, wage differentials tend to adjust only slowly in response to changes in underlying demand and supply conditions. In Britain, wage differentials associated with skills and responsibility were compressed considerably in the 1960s; they widened slightly in the 1980s, but still remain low in comparison with the Continent. For example, a section foreman in Britain earns some 40 per cent more than an unskilled person in Britain, compared with a differential of 70 per cent in France and Germany.[21] I suspect differentials will need to widen further here if we are to rely on them alone (that is, without obligatory training) to provide incentives for youngsters to acquire vocational skills and qualifications.

The pressures on the labour market ensuing from automation, combined with increased international competition in manufactured goods, have required policy makers to shift their attention towards raising the educational attainments of those most affected; that is (as indicated at the outset of this lecture), there needs now to be greater concern with the schooling attainments of average and below-average school-leavers than simply with those top-attainers who are to join the ranks of university graduates. In the remainder of this lecture I propose to look in international perspective, and in some detail, at some relevant aspects of British schooling. Before coming to that, I must digress — if only briefly — on a general issue relating to the lack of clarity of our vocational qualification system, which inhibits Britain's youngsters

[21] For the course of differentials in Britain and Germany, see the article by the present writer in *NIER* (February 1988), 40; and the sequel, including France, in Steedman *et al* (1991), 71.

undertaking courses of vocational qualifications to the extent that they do on the Continent.

The New British System of Hallmarking Vocational Qualifications

The task of standardising our previous (rightly-called) 'jungle' of vocational qualifications into four or five levels was handed by the Government in 1986 to a newly-formed National Council of Vocational Qualifications. The main object was to make the system more understandable both to employers and potential trainees; if the system were better understood, it would increase employers' demand for properly qualified personnel, and ultimately increase youngsters' determination to acquire the necessary skills and qualifications. Essentially, it was hoped that a better system of 'Hallmarking' would improve the working of the market for skills. Unfortunately that Council went much beyond that task — without adequate resources, background research or piloting — and revised fundamentally the whole system of the testing of vocational qualifications, and their specified occupational breadth and content. Let me list some eyebrow-raising aspects for the award of vocational qualifications in this country which contrast with Continental systems. Written examinations have now been virtually abolished as part of our new National Vocational Qualifications (NVQs); the marking of individual candidates' practical tests by external examiners — who do not know the candidate — has also been abolished; college instruction and tests in specific general educational subjects (e.g. English and mathematics) also do not form a distinct component of our vocational examinations. The new qualifications are of a narrow 'skill-test' type, rather than the broad career paths which form the basis of a much more limited number of Continental qualifications. These all seem to me highly debatable decisions, leading to lower reliability and lower marketability of such qualifications.[22] A

[22] Electricians are amongst the exceptions who have succeeded in retaining written examinations (City and Guilds course 236) as pre-requisites for the award of NVQs, and hence for the receipt of government training subsidies for that country's apprentices. In order to promote the Government's plans for NVQs, training subsidies were made conditional on following NVQ schemes of training; since the latter require, in general, the exclusion of written examinations, taxpayers' funds continue to be used to eliminate the written testing of knowledge — in the way that was previously taken as essential here, and continues as essential on the Continent.

parliamentary inquiry now seems to be necessary to look into these changes from previous practice in this country, and into the increased divergence from established Continental practice.

More recently the Council has proposed an additional series of broad courses for full-time study in secondary schools and colleges — a dozen so-called *General* National Vocational Qualifications (in contrast to their highly specific NVQs); these have been piloted in the past year in selected schools. They are intended to provide a general introduction to a 'sector of the world of work'; they are not intended to have specific occupational relevance, and cannot do much to bridge the skills gap with the Continent. We shall have to wait and see whether the vocational content of these full-time college-based courses will be sufficient to commend them to employers.

School-leaving Standards

Unless youngsters leave school with adequate basic educational attainments, subsequent vocational training and education may become too costly both for trainer and trainee. In considering the adequacy of school-leaving standards in Britain, I propose to look not so much at national *inputs* of resources into schooling in terms of average years of schooling or class sizes, which have been the preoccupation of too many economists when writing about education, but rather at the *outputs* of the system in terms of pupils' attainments. To enable us to look in some depth at the issues in the time available here, and because of our concern with the economic efficiency of the workforce, we shall focus on just two vocationally-relevant areas of the school curriculum: mathematics, and what we shall call 'practical subjects' — such as metalwork, technical drawing, textile work.

The need for widespread competence in mathematics requires little elaboration: it is needed at a *basic* level by almost everyone when going shopping; at an *intermediate* level by craftsmen who have to calculate the volume of raw materials or the size of electrical flows, or in business transactions when calculating hire-purchase terms; and it is often needed at an *advanced* level in scientific work. Much teaching of science even at secondary schools hinges on basic algebraic manipulation (for example, the ability to transform simple equations in Newton's laws of motion and Ohm's law). Mathematics is a subject in which the average British pupil has for long been known to fall distinctly behind in international comparisons; and British employers, in listing their complaints about school-leaving standards, have repeatedly found it necessary to include poor mathematical attainments.

The most recent large sample international comparisons of pupils' attainments in mathematics was carried out in 1991; but the essential features of (what we may call) the 'British problem in mathematics' became evident in quantitative terms in the first major international comparison carried out in 1963–4. Let us begin there. That first *International Study of Achievements in Mathematics*[23] was carried out in a dozen countries; 70 internationally-agreed questions were set to about 3000 pupils in each country at age 13 — the latest age when pupils in virtually all the countries concerned were in compulsory full-time education (additional tests were set to pupils in their pre-university year, aged 18–19, but the findings are not immediately relevant here: only a small fraction of top attainers are at school at that age, and that fraction varies substantially from country to country). The study was carried out by an international academic group known as the International Association for the Evaluation of Educational Achievement (known as IEA for short). The ostensible object of these studies was to compare the factors in different countries that contribute to successful learning; for example, how class size and time devoted to this subject at school (or in homework) are related to high scores within each country. There was less ostensible concern amongst the sponsors of these studies with ranking countries by average attainments; nevertheless, when these studies are taken together, important inferences may be drawn as to the nature of Britain's educational problem.

The distribution of test scores in mathematics for all 13 year-olds

[23] See the 2 vols with that title, ed. T. Husen (Almquist & Wiksell, Stockholm, 1967). Much the same ground was covered by N. Postlethwaite, *School Organisation and Student Achievement: A Study Based on Student Achievement in Mathematics in Twelve Countries* (Wiley, 1967). For an over-critical review, H. Freudenthal, 'Pupils' achievements internationally compared', published on pp. 127–86 of the journal he edited, *Educational Studies in Mathematics*, vol. 6, no. 2 (Reidel, Dordrecht-Holland, July 1975). The original aims of these studies may have been only partially achieved; but important lessons are to be drawn from them, especially if successive studies are considered together and in conjunction with other information. They provided invaluable starting points in the National Institute's observations of schools in Britain and the Continent. Of particular concern, from the point of view of assessing Britain's schooling performance, has been Britain's much poorer response rate to the surveys, with the likelihood that weaker schools and weaker pupils were not adequately represented; the true shortcomings of British pupils' attainments are thus likely to be understated in these surveys (see nn. 30 and 37 below on Britain's response rates to the 1981 and 1991 surveys).

in England in that first international study is summarised here in Table 2 in comparison with France, Germany, the Netherlands, Japan and the United States. If we define low attainers as those with a score of 5 or under — out of a maximum score of 70 — as many as 24 per cent of all pupils in England were found in that category, compared with only 8–10 per cent in Germany, the Netherlands and Japan, and 14 per cent in France. None of the other countries in that inquiry had as high a proportion of low attainers as England, though the United States (on which more will be said in a moment) came close to England. Roughly speaking, we may say that there were 2–3 times as many low attainers in England as in our leading European industrial competitors.

We can examine the gap of low attainers more directly from that

Table 2. Summary distribution of scores in international mathematical tests of 13 year-old pupils, England compared with five other countries 1963–4.

Score[a]	England	France	Germany[b]	Netherlands	Japan	US
<5	24	14	8	10	8	22
6–30	49	68	59	57	38	62
31–51	22	16	30	25	40	14
>51	5	2	3	8	14	1
	100	100	100	100	100	100
Average score	19	18	25	24	31	16
CV(%)[c]	88	68	53	67	54	82

[a] Out of maximum 70.

[b] Approximate: estimated from original tabulation as follows. Germany participated only on the basis of classes containing *most* 13 year-olds ('population 1b', not 'population 1a'. That is, the German figures as originally published omitted the very highest attainers of that age who had 'skipped a class' and were now in a higher class, and also omitted the very lowest attainers of that age who had 'repeated' a year and were now in a lower class. For convenience of exposition here we have adjusted the original published figures for Germany by reference to the differences between the alternative bases reported for neighbouring countries with similar policies on class repeating: France, the Netherlands and Belgium. The adjustment was important only for the lowest category of pupils (a score of <5), who would have been shown as accounting for only 4 per cent of all German pupils instead of the estimated 8 per cent as shown above.

[c] Coefficient of variation (standard deviation divided by average, derived from original source).

Source: From the IEA study (see text, n.15), vol. II, p. 22 ('population 1a' — *all* 13 year-olds; totals may not sum to 100 because of rounding).

IEA inquiry by comparing the scores of English pupils in Secondary Modern schools with the scores of German pupils in *Hauptschulen* — these schools catered for pupils who were broadly in the lower section of the academic attainment range in each country. Average scores of 12.9 were recorded for Secondary Modern pupils in England, and 22.4 for *Hauptschule* pupils in Germany: an astonishing gap![24] On the basis of IEA tests administered at that time to parallel groups of pupils who were a year younger, it appears that a one-year difference in ages was associated with an average gain of some 4.4 points by Secondary Modern pupils; subject to obvious qualifications, the difference between the English and German average scores (in this lower section of the attainment range) can thus be said to be equivalent to an English lag behind Germany of just over two years of English schooling. Yet another way of expressing the contrast is to note that the German average score of 22.4 by pupils in the least academic stream of schools (those catering for the *lower portion* of the academic ability range was close to the average score by *all* English pupils of 20:1; very broadly speaking, the German system had raised the attainment of its lowest half of pupils to that of the average of *all* pupils in England.[25]

On the other hand, for pupils in the top attainment range shown in Table 2 — those scoring over 50 out of a maximum of 70 points — England's 5 per cent of pupils in that category compared favourably with France and Germany's mere 2 per cent; nor were English top pupils too far below the 8 per cent of the Netherlands, though — already then — they were substantially below Japan's 14 per cent.

England thus had an unusually large share of low attainers, combined with a respectably large share of high attainers. In terms of the coefficient of variation (final row of Table 2), pupils in England had a 60 per cent higher variability in attainments than pupils in Germany and Japan, and a 30 per cent higher variability than France and the Netherlands. Such wide differences in variability, it seems to me, deserve as much attention as differences in *average* scores to which attention is usually directed. In the calculation of *average* scores the

[24] The comparisons in this paragraph are, in reality, even less favourable to England since its Secondary Modern schools accounted for a somewhat greater proportion of all pupils than the German *Hauptschulen*; i.e. the English pupils on average came from a higher slice of the attainment range than the German pupils.

[25] See Appendix B of the article by the present writer and Dr Karin Wagner (of the Technical University, Berlin) in the *NIER* (May 1985), for sources and details of the adjustments.

relatively good performance of English high attaining pupils partly offsets, and hides, the relatively poor performance of England's low attainers. A related general point was made some 20 years ago by the American educationist Professor Benjamin Bloom, one of the main motivators of these international studies: 'across the world, differences in attainments by the bottom 90 per cent [of pupils are much greater] than amongst the top 5 per cent'.[26] His remark has greater weight today because of the technological developments that continue to depress the relative demand for those with low schooling attainments.

Because of its economic pre-eminence, the United States must be referred to here, but we shall not need to look at it in great detail. The success of its educational system, considered as a whole, relies on providing the median pupils with *full*-time schooling until 19, compared with under 17 in Britain and Germany. It is thus a highly expensive system. Attainments at secondary school in the US, however, develop slowly. In terms of the proportion of low-attaining pupils, the US came second from the bottom in the international study just quoted — i.e. only just above England — with 22 per cent of its pupils in that category compared with Britain's 24 per cent. In addition, the United States was at a disadvantage in having fewer high attainers than in England (for example, only 1.4 per cent of US pupils, compared with 5 per cent of English pupils, attained a score of over 50). The *average* score for all US pupils in that survey consequently came out lower than England, even though the US did not have quite as many low attainers.

The educational basis for the economic success of that great country thus clearly does not rest on high attainments at secondary school; on the contrary, deficiencies at that level of schooling — and particularly of pupils on non-academic school tracks — are now of as much public concern there as they are here. Unemployment among the young and unskilled is a serious problem there; and average real earnings per hour, far from rising as a result of technical advances, have slightly declined over the past 20 years, and more go for those who are unqualified. Methods of schooling in Continental Europe and Japan are now looked to in the United States as sources of inspiration for improving US school-leaving standards; from the point of view of our concerns

[26] See 'Implications of the IEA studies of curriculum and instruction', ch. 3 in *Educational Policy and International Assessment*, ed. A. C. Purves and D. V. Levine (Berkeley, California, 1975), pp. 78–9.

here, the US is thus to be considered more as a country suffering from similar educational problems to those of Britain, rather than providing any exemplary message which may be of immediate help.[27]

International surveys of pupils' attainments were subsequently extended by the IEA to other subjects. Tests of science attainments by 14 year-olds were carried out in 1970. The results again pointed to English pupils' lower average scores and a considerably greater variability: the coefficient of variation of English scores was 25–30 per cent greater than in Sweden, the US, Hungary and Japan. Scores attained by the lowest tenth of pupils in Germany were attained by the lowest quarter of pupils in England. In science, as for mathematics mentioned above, it thus appears that England had 2–3 times as many low attainers as Germany.[28]

Tests of reading comprehension by 14 year-olds were also carried out by the IEA in 1970; they again showed higher variability in England as compared with three other countries for which that analysis was carried out — Sweden, the US, and Hungary — with the lower quartile of pupils appearing particularly low.[29]

Scotland is often thought to have a superior schooling system to England's. This seems to be modestly supported by the IEA tests for reading; but, surprisingly as it may seem, Scottish pupils' attainment in mathematics and science were almost indistinguishable from England's in respect of low averages and high variability of scores.

But let us return to mathematics and look at more recent results. The IEA carried out a second survey of mathematical attainments in 1981, that is, 17 years after its first study of that subject; in that intervening period English secondary schooling had been substantially transformed from a selective to a comprehensive system. Some 20 countries took part in this second study (compared with a dozen in the

[27] R. Marshall and M. Tucker, *Thinking for a Living: Education and the Wealth of Nations* (Basic Books, NY, 1992), esp. pp. 154–5 on the difficulties of using German 'top-of-the-line machines' in the US because of the inadequate technical training of US operatives. See also I. C. Magaziner *et al., America's Choice: High Skills or Low Wages: Commission on the Skills of the American Workforce* (National Center on Education and the Economy, Rochester, NY, 1990).

[28] Based on calculations of the variability of pupils' scores in seven of the participating countries prepared by Professor Postlethwaite — then president of the IEA — for a National Institute conference; see T. N. Postlethwaite, 'The bottom half in lower secondary schooling', ch. 8 in *Education and Economic Performance*, ed. G. D. N. Worswick (Gower, 1985), p. 94. The comparison of science attainments by the lowest quarter of pupils is derived from Chart. 8.1 there, and is approximate.

[29] Ibid. table 8.1, charts. 8.1 and 8.2.

first), including a number of developing countries. Japan again came top with an average score of 62 per cent, followed by the Netherlands (57), Hungary (56), France (53), Belgium (52); Germany did not participate in this round. England's average score of 47 per cent was distinctly lower but, as in the first survey, was slightly above Sweden (42) and the US (45).[30]

On the basis of similar tests administered to parallel groups of pupils who were a year younger than the main sample (as in the previous comparisons with Germany mentioned above), it may be said that average Japanese pupils were nearly two years ahead of average English pupils in 1981: there had been negligible change in the advantage of Japanese pupils, on this measure, since the IEA study of 1964.[31] Taking an average of the scores of the Netherlands, France and Belgium to represent Western Europe, England could be said — on the same basis — to lag by about a year's schooling behind this Western European group (it may also be mentioned that formal schooling starts a year later in these countries than in Britain — at age 6 rather than 5 — so that two years of progress are lost under the British system). France's series of initiatives in that period to raise educational attainments seemed to have borne fruit since its average score in the 1981 tests was much the same as for the Netherlands and Belgium, whereas in 1964 France had been distinctly lower.

The variability of mathematical attainments amongst pupils in 1981 can be judged on the basis of 37 so-called 'anchor-item' questions that were set identically both in 1964 and in 1981.[32] For English pupils, a

[30] From the graphs in ch. 6 (by D. F. Robitaille) in D. F. Robitaille and R. A. Garden (eds), *The IEA Study of Mathematics*, vol. II (Pergamon, 1989), pp. 105, 111, 115, 117, 119. The response rate to this survey in England and Wales was only 36 per cent, and very much lower than elsewhere. The details are not easily accessible, and may be noted here. A total of 248 schools were selected for participation in England and Wales, but only 133 co-operated (54 per cent); of the 4041 pupils in the co-operating schools, only 2678 were in the achieved sample (66 per cent; see R. A. Garden, *Second IEA Mathematics Study: Sampling Report* (US Department of Education, duplicated 1987), pp. 61 and 88). The consequential possible upward biases in the recorded results for England were not investigated at the time. The issue deserves attention since England and Wales have recently decided to participate in the third IEA mathematics study to be held in 1994.

[31] The adjustments for age are detailed in my paper in the *NIER* (February 1987), 42; and n. 15, at 54.

[32] No full investigation of the frequency distribution of scores for the complete set of questions was undertaken on this round by the IEA. For calculations on the anchor-items, see M. Cresswell and J. Gubb, *The Second International Mathematics Study in England and Wales* (NFER-Nelson, 1987), p. 66. Additional calculations are available on the basis of a set of 40 'core questions' (to be distinguished from the 'anchor-items': the 'core' excluded questions

small reduction in variability occurred between 1964 and 1981, of about a tenth as measured by the coefficient of variation. However, compared with other countries the variability of English pupils' attainments remained high, at some 50 per cent above France and Japan, and considerably higher than Sweden and Hungary; but it was now slightly exceeded by the US.

The 37 'anchor item' questions included a greater share of basic mathematical topics; a not untypical question was

> On level ground a boy 5 units tall casts a shadow 3 units long. At the same time, a nearby telephone pole 45 units high casts a shadow — what is the length of that shadow?

In the survey of 1964 that question had been answered correctly by 56 per cent of English pupils; by 1981 it was answered correctly by only 29 per cent of English pupils (compared with 61 per cent of Japanese pupils). The questions in both years were set in multiple choice form, based on ticking one of five possible answers; I have made the conventional adjustment for guessing in quoting percentages of those answering correctly (based on the simple assumption that those who did not know the correct answer may have marked it correctly by random ticking).[33] That is to say, in broad terms, this question could be answered correctly in England in 1981 by hardly more than that proportion of pupils who had previously been in the grammar school stream.

On all 37 anchor questions, English pupils in 1981 were able to answer correctly only some 30 per cent of questions (adjusted for guessing), which is close to the example just considered. There was only one out of the 37 anchor questions in which English pupils did better in 1981 than in 1964; in six questions there was no statistically significant difference between these two years; but in 29 out of the 37 questions English pupils in 1981 did significantly worse than in 1964.[34]

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set to various sub-samples of pupils) in Postlethwaite, op. cit., pp. 96–7 (the countries referred to there as B, D, E and F are Sweden, France, Hungary and Japan.)

[33] If p is the fraction ticking the correct response, the adjustment required is a deduction of (1–p)/(n–1), where n is the number of possible choices (this follows from assuming that p consists of P, the proportion who really know, plus an equal fraction of the remainder (1–P)/n who are assumed to distribute their ticks at random over the alternatives). This conventional adjustment is subject to fairly obvious limitations; but it seems to me better to quote the results of multiple choice tests after such an adjustment than without it.

[34] Cresswell and Gubb, op. cit., pp. 54–64. Not too much attention should be paid to the single question in which English pupils performed statistically 'significantly' better in 1981 since that was an untypical question: even in 1981 a mere 13 per cent of pupils gave the right answer (after adjusting for guessing).

Grouping these 37 anchor questions into arithmetic, algebra, geometry and statistics, England was the only country which showed declines in average scores for all four groups.[35]

This is a remarkable record of decline. Even after allowing for a slight difference in average ages of pupils in the two surveys (they were about three months younger in the later survey) it appears, from a calculation based on attainments of pupils of different ages, that the fall in scores in the period 1964–81 is notionally equivalent to a loss of some 11 months of learning.[36] In other words, in such basic mathematical topics, pupils aged 14 in 1981 were on average only at the level that 13 year-olds had reached in 1964.

There is little doubt that most countries in the past generation have shifted their mathematical curricula to varying extents away from traditional — especially arithmetical — topics, partly because of the increasing availability of cheap calculators, and partly because the 'modern mathematics' movement led to the inclusion of a series of new topics. It goes without saying that if there is to be progress in the curriculum as a result of the inclusion of new topics, it would not be surprising to find a decline in the time devoted to older topics, accompanied by a decline in pupils' attainments in those topics. Judging from this comparison of the 1964 and 1981 international tests, it seems that changes in that period — whether in curricula, examination systems, school organisation or other matters (teacher training?) — were less successful in Britain than in other countries, and did not bear any obvious fruit when measured on internationally-agreed tests.

In 1990 there was a further round of international tests of mathematical attainments of pupils aged 13. The tests were carried out by a US agency (the Educational Testing Service of Princeton, NJ, which had much experience of testing within the US), and were sponsored by the US Government because of its increased concern with low standards there; the tests were named the International Assessment of Educational Progress (IAEP, not to be confused with the IEA which was the body responsible for the previous studies). Some 20 countries participated; summary results are shown in Table 3 for England and

[35] Robitaille and Garden, op. cit., vol. II, pp. 160ff.

[36] This follows from table 3.27 in Creswell and Gubb, p. 66, by comparing samples of pupils aged 14:1 in 1981 with a suitably weighted average of those who in the 1964 sample (population B) were aged 13:5 and those aged 14:4. Other possible reasons for the decline in performance considered by these authors (pp. 66–7) do not seem important, except for the change in curriculum coverage considered below.

Table 3. Scores in international mathematics tests of 13 year-old pupils (averages and extreme deciles), England compared with four other countries, 1990.

	England	France	Italy	Switzerland	US
Arithmetic average	59.5[a]	64.2	64.0	70.8	55.3
Highest decile	89.3	89.3	88.0	93.3	82.7
Lowest decile	32[b]	37.3	36.5	50.7	29.3
Relative variability (%)[c]	95	81	81	60	97

[a] Adjusted for low response (see present text, n. 37).
[b] Difference between highest and lowest decile as percentage of arithmetic mean.
[c] Emilia-Romagna only (sample response rate satisfactory at 78 per cent).

Source: IAEP Study, 1990; extracted from Lapointe *et al.*, op. cit., p. 145.

three other countries. Within Europe, Switzerland's average score was highest at 71 per cent correct, followed by Hungary (68), France (64), Italy (64) and then England at 60 per cent; the US average score was only 55 per cent. This was the first time Switzerland had participated in such international comparisons. The Netherlands, which was the top attaining European Country in the 1981 IEA study, did not participate; nor did Germany. On a broad view we may, however, regard Germany, the Netherlands and Switzerland as pursuing teaching approaches with considerable elements of similarity (predominantly whole-class teaching, emphasis on mastery of basics); it may be adequate for our purposes here to regard each of those countries as representative of that Western European group. Japan also did not participate; but two Asian countries, following educational approaches similar to Japan's, did participate — Korea and Taiwan; their average scores, both at 73 per cent, were just slightly ahead of Switzerland's 71 per cent.

Switzerland's performance was very remarkable also in that its lowest tenth of pupils scored distinctly higher than the lowest tenth in any other country.[37] A full third of English pupils were able to reach

[37] A. E. Lapointe, N. A. Mead and J. M. Askew, *Learning Mathematics* (Educational Testing Source, Princeton NJ, 1992), derived from fig. 1.1, p. 18. The response rate in England was a highly unsatisfactory 47 per cent compared with some 80 per cent for France, Switzerland and Italy; on the basis of other studies it seemed likely that low attaining schools tended not to participate (see, e.g. D. Foxman, *Learning Mathematics and Science: The Second International Assessment of Mathematics and Science in England*, (NFER, 1992), p. 3 and n. 6). NFER subsequently kindly co-operated with our request to compute adjustment factors for response-bias based on published GCSE attainments of schools that were approached for the IAEP survey and of those schools that participated; the originally published score for the

no more than the score of the Swiss lowest tenth.[38] In other words, there were some three times as many low achievers in mathematics in England as in Switzerland, measured on the same international criterion; this is similar to the ratio noted in the 1964 comparison between Germany and England. Switzerland's success with 'low attainers' as recorded in this IAEP survey fully concurred with observations by our teams of teachers and school inspectors on visiting Swiss schools last year. At the top end of the attainment range, the IAEP survey suggests (see Table 3, second line) that England in 1990 no longer displayed the advantage over other countries that appeared in the 1964 tests. US attainments at this age remained slightly weaker than Britain's.

Moves towards a National Curriculum and its Problems

The variability of English pupils' attainments in mathematics was given prominence in the 1982 official inquiry by the Cockcroft Committee into the teaching of school mathematics in England and Wales. 'A seven year difference' in pupils' attainments at age 11 was identified by the Committee in its report, *Mathematics Counts*, and has subsequently been widely quoted; that is to say, a typical cross-section of pupils aged 11 might be expected to contain pupils ranging in attainments from those of average pupils aged 7 to those of average pupils aged 14.[39]

The extent of variability in attainments of pupils of a given age is an important issue. It determines the optimum organisation of classes and the choice of teaching methods. Let us note three critical reser-

lowest decile of 34.5 (Lapointe *et al.*, p. 145) was consequently lowered to 32, as quoted in the table above. There was no other adjustment of any substance. This method of allowing for bias in the results for England can be regarded as only partial for the following reason. Contrary to sampling procedures in other countries (which took a representative sample of pupils throughout the attainment range in each school), the procedure in England was based on sampling whole classes; classes in mathematics in English comprehensive schools are usually 'set' on the basis of ability, and it consequently seems likely that there were additional biases within schools as a result of lower response by low attaining *classes*. The method of adjustment adopted here accounts, at a guess, for perhaps no more than half the total bias. Because of the much higher response rates in the other European countries mentioned, no adjustments of comparable magnitude are needed there.

[38] Based on graphical interpolation from summary distribution published by Lapointe *et al.*, p. 145 (OECD, *Education at a Glance* (1992), p. 123, published a curious alternative table which is not wholly consistent with that by Lapointe).

[39] HMSO, 1982, para. 342.

vations that might be attached to the bold summary statement in the report of the Cockcroft Committee. First, we need to be clear as to the *proportion* of pupils having attainments within that seven-year span: the range spanned, for example, by 80 per cent of pupils may be expected to be only about half that spanned by 99 per cent of pupils (it would be almost exactly a half if attainments followed a statistically Normal distribution). Any stated span is thus arbitrary unless the proportion of pupils covered is stated. What proportion did the Cockcroft Committee have in mind? Nothing was said explicitly. But specimen test questions quoted in their report suggest that the middle 70 per cent of pupils might have been in the Cockcroft Committee's mind when speaking of a 'seven year difference'. A second reservation is that the empirical evidence produced was based, not on the results of a broad range of mathematical tests, but on just two or three specimen questions.[40] These were adequate to confirm that pupils at a given age vary; but they were inadequate in relation to the precision conveyed in mentioning 'seven years' as a measure of variability. Thirdly, there was no recognition that the variability of pupils' attainments might be substantially lower in other countries, nor that the organisation of schooling might have a bearing on the variability of pupils' attainments. In short, the seven-year difference was put forward as something close to an established fact of nature — as immutable for practical purposes as, say, the 8 cm standard deviation of adult men's heights in Britain — but without scientific foundation.

This 'stylised fact' subsequently had fundamental consequences for the organisation of the whole spectrum of curriculum subjects in British schools. When the National Curriculum (NC) framework was pre-

[40] Which number is one more than 6399? The Cockcroft Report says: 'the average child can perform this task at age 11 . . .', and 'there are *some* 14 year-olds who cannot do it and *some* 7 year-olds who can' (para. 342, our italics); but *some* is not defined. A second comparison quoted by Cockcroft was based on simple fractions: how much is two-fifths of 40, or three-quarters of £24; the former can be answered by the top 15 per cent of 10 year olds, the latter cannot be answered by the bottom 15 per cent of 14–15 year-olds. The only source quoted in the Report (p. 100) relates to the first question (6399); but the source quoted (K. M. Hart, ed., *Children's Understanding of Mathematics 11–16* (Murray, 1981), remarkably enough, does not provide this information (the additional sum was mentioned by Margaret Brown in ch. 4, p. 49, but not the varying proportions answering correctly according to ability range). The same sum appeared in M. Ward, *Mathematics and the 10-Year-Old* (Schools Council Working Paper 61, Evans/Methuen, 1979), pp. 74–5, showing that 41–8 per cent of all 10 year-olds can answer correctly; but there was no reference to other ages or particular ability levels (I am grateful to Professor Margaret Brown of King's College, London, for help with these sources).

scribed under legislation at the end of the 1980s, levels of attainment were required to be set down for each subject corresponding, first, to the *average* pupil at each age; secondly, the expected *variability* of attainments at each age was officially indicated in graphical form as 'a rough speculation about the limits within which about 80 per cent of pupils may be found to lie' (note 80, and not 70, per cent of pupils as might be inferred from the Cockcroft Report).[41] This was intended to guide the breadth of levels of study to be provided for pupils in each age-group. That graph (the 'TGAT graph', named after the NC Task Group on Assessment and Testing) indicated that at age 11, 80 per cent of pupils were expected to have attainments lying between those of average pupils aged 8–14; that is, a six-year span was then posited for the central 80 per cent of pupils.[42]

Whatever reasoning lay behind all this, Britain is now in the remarkable position of having incorporated — as part of its scheme for a National Curriculum — a specified degree of variability in attainments for pupils within each age-group. As we have seen, the variability of English pupils' attainments is unusually wide by international standards — which is another way of saying that we have an unusually long tail of low achievers. An unfortunate accompaniment of the present approach is that no explicit target for a reduction in that variability has been put on to the political agenda; nevertheless, scores from tests set to all pupils (the controversial Standard Assessment Tasks — SATs) as part of the National Curriculum arrangements are now being used to identify weak schools for investigation by the inspectorate. That process can only be beneficial.

So much on variability of pupils' attainments. The international

[41] *National Curriculum: Task Group on Assessment and Testing: A Report* (Chairman: Professor P. J. Black, DES; undated, c. 1988), fig. 1, printed between paras. 104 and 105. The notion that all school subjects can usefully be put on to a linear ten-level measuring rod, independent of the age of the pupil, is itself debatable; it seems more applicable, for example, in mathematics and foreign languages than in history or English. But even in mathematics, what should be taught to an advanced 9 year-old is not the same as should be taught to a weak 16 year-old — though on the TGAT scale both would be at Level 4. These fundamental matters are now being re-considered by the new School Curriculum and Assessment Authority under Sir Ron Dearing.

[42] On the assumption of a statistical Normal distribution, the *six*-year span posited by TGAT for the central 80 per cent of pupils corresponds to only a *five*-year span for the central 70 per cent for which the Cockcroft Committee had posited a seven-year span. There was thus a substantial contraction, as far as official thinking was concerned, from Cockcroft's seven-year to the TGAT five-year span of attainments at age 11. If there was any new evidence on this, it was not produced.

surveys of mathematics have also been important in identifying that the weakness of English pupils is particularly severe in one branch of that subject — arithmetic. Within arithmetic, three sub-branches were distinguished by the IAEP study of 13 year-old pupils in 1990: basic concepts (e.g. what is a decimal number?); problem-solving (does the pupil know which technique to apply to a problem in an applied context?); and procedural knowledge (can the pupil actually subtract or multiply?). It is in this last sub-branch — procedural knowledge — that British pupils were most lacking. Two examples may be quoted. A subtraction sum with one decimal place (21.2 – 3.4) was answered correctly by 85 per cent of pupils in Korea and Taiwan, by 80 per cent of pupils in France, Italy and Switzerland — but by only 49 per cent in England and Wales.[43]

Multiplication was more difficult: 9.2 × 2.5 was calculated correctly by 70 per cent of pupils in Korea and Taiwan, by 55 per cent in France, Italy and Switzerland — but by a mere 13 per cent of English pupils: fewer than in any of the 20 participating countries.[44]

These examples show how *average* English pupils compare in arithmetic with average pupils in other countries in the most recent international tests. To delineate how English pupils in the lower half of the academic attainment range compare internationally in specific arithmetical topics is more difficult, since the systematic international surveys considered so far have not been published in relevant detail. Some comparisons can, however, be drawn between one of the German *Länder*, Baden-Württemberg (main city: Stuttgart) and England and Wales. In that part of Germany, all pupils in schools of the 'Secondary Modern type', catering for the less-academic 40 per cent of the attainment range (*Hauptschulen*), are required to take leaving examinations in core subjects including mathematics, at an average age of just under 16. They can conveniently be compared with selected similar questions set to representative samples of pupils in England and Wales at an

[43] The example is given in Lapointe *et al.*, p. 29; it was a multiple choice question with four alternative answers. The results for each country quoted above are based on unpublished tables kindly supplied by the authors, and have here been adjusted for guessing. For the deficiencies in 1964 of English pupils in arithmetic, see Husen, op. cit., p. 32, tables 1.7 and 1.8.
[44] This was an open question, and no adjustment for guessing was necessary. Foxman remarked (op. cit., p. 17) that even Third World countries participating in the comparisons did better on this question than Britain; however, it must be remembered that many 13 year-olds are not registered at school in some Third World countries (Brazil, China), and the results recorded in such international tests are thus likely to be biased upwards.

average age of 15 years and 8 months by the Assessment of Performance Unit (APU) of the Department of Education.

These comparisons have the advantage for our purposes that the pupils are older than in the international surveys mentioned previously, and near the end of their compulsory schooling: apprenticeship or traineeship is the next step for most of them in Germany. How well are they prepared for that step? Let me quote just one example. A simple add-and-subtract sum (with both one and two decimal places) was set to English pupils by the APU:

$$2.6 - 4.12 + 6.3 - 0.44 = \ldots$$

It was answered correctly by a mere 24 per cent of *all* English pupils, that is, by pupils throughout the whole attainment range; for English pupils in the lower half of the attainment range, it has been estimated that a negligible 4 per cent would be able to answer correctly.[45] In German *Hauptschulen* (as mentioned, schools catering for the lower half of the attainment range), a similar but more difficult question was set in the leaving examinations for 1991, to be answered — it needs to be emphasised — *without* calculators, as follows:

$$5634.3 - 3194.02 + 4571.6 + 378.98 - 856.75 = \ldots$$

It was answered correctly by 76 per cent of pupils in those German schools. Only the top fifth of all English pupils, with 62 per cent correct, were able to approach the attainments of the German lowest two-fifths of all pupils. Arithmetical competence instilled at this level is helpful both to the craftsmen who has to calculate his bills of quantities, as well as to the many other pupils in *Hauptschulen* who, for example, take up traineeships as accounts or sales assistants.

It is sometimes suggested that English pupils compensate — in some sense — for their arithmetic deficiencies by excelling in other topics in mathematics, particularly questions on understanding bar charts and pie charts, or calculating simple averages — questions that are sometimes put under the impressive heading of 'Data analysis, probability and statistics'. It is, however, more correct to say that

[45] For further examples, see Prais and Wagner (1985), Appendix A, pp. 73–4. The analysis by attainment range (carried out by the National Foundation for Educational Research) was based on attainments in all mathematics questions in the APU test taken together, rather than on attainments in *all* subjects — which would be closer to the German basis of classifying pupils. If the latter classification could be carried out, no doubt more than 4 per cent would be found capable of answering that question correctly: but probably not many more.

English pupils have not fallen as far behind in questions under that heading, probably because such questions in international tests were deliberately kept arithmetically very simple (e.g. using only single-digit numbers in calculating averages). Thus, the 1990 IAEP comparisons for questions in this 'data analysis' category put England and Wales a little below Switzerland, indistinguishable from France, and a little ahead of Italy. Geometry is also sometimes mentioned as an area in which English pupils are 'strong'; but in geometrical questions in those 1990 comparisons, English pupils in fact came slightly below France, Italy and Switzerland.[46]

The introduction of pocket calculators is often advanced in Britain as a justification for the fall in pencil-and-paper and mental arithmetic. Calculators are now treated as compulsory in Britain under the National Curriculum, starting from primary school; but in other industrially highly successful countries — for example, Japan, Germany, Switzerland — concern that the child's mind needs first to become fully adept in basic arithmetical processes has led to an insistence on deferral in the use of calculators in school to the age of about 14.[47] The danger of too early a use of calculators has recently been emphasised by Professor Geoffrey Howson (Professor Emeritus of Mathematical Curriculum Studies at the University of Southampton); as he put it: 'a child is likely to find the soroban or abacus more useful than a calculator for learning the fundamentals of number'.[48] I find it difficult to reject the judgement of the many Continental teachers (and heads of training in places of employment) to whom we have spoken: without exception they condemned the early introduction of calculators in schools because of its deleterious consequences for the development of pupils' mathematical capabilities.

The 'New Mathematics' (or 'Modern Mathematics') movement of the past generation must bear part of the responsibility for lowered

[46] See Foxman, p. 13. The previous 1981 study (carried out by IEA) suggested that English pupils performed satisfactorily in geometry; but that study was marred by a 36 per cent response rate for schools in England and Wales (see n. 30 above), even poorer than the 1990 IAEP study, and was therefore likely to have a greater upward bias.

[47] For the sake of clarity: everyone agrees that the use of calculators should be taught at school — the issue is the *correct age* for doing so. There is now a very clear contrast between Germany and Britain in school examinations at age 15–16: calculators are not permitted at all in, for example, *Hauptschule* leaving examinations in Baden-Württemberg; whereas in Britain they are compulsory at GCSE.

[48] G. Howson, 'The Mathematics curriculum towards the year 2000' (forthcoming in the USA) *J. Mathematical Behavior* and (in Japanese) in *J. Jap. Soc. Math. Edn.* (1993).

emphasis on arithmetic. This movement attempted (a) to broaden the range of mathematical topics taught at early ages, by including topics until then considered suitable only at an advanced level; and (b) to broaden the style of teaching, emphasising 'discovery' methods of learning and data-gathering as against what they condemned as 'rote-learning'. The beginnings of this movement are often traced to 1957 when Sputnik was launched, and Western countries felt a near-hysterical urge for a revolution in mathematics teaching in order 'to catch up with Russia'. But there were also important predecessors who started from notions of the natural psychological development of children's conceptual levels (Piaget), and from the logical foundations of mathematical knowledge (Bourbaki) — though it is questionable whether these notions have any great importance in deciding the optimum sequence of topics for teaching. The movement gained strength following the 1959 OEEC conference on mathematics teaching held at Royaumont. A consequence of these changes was that learning time both at primary and secondary schools was directed away from proficiency in basic arithmetic. This new approach was seized upon strongly in Britain, partly because it coincided with the move towards comprehensive schools and mixed ability teaching, and the latter required a search for new approaches to teaching.

Topics introduced as part of the New Mathematics movement included: set theory, alternative number bases, vectors, matrices, tessellations, symmetry, probability. Almost all this new material was originally intended for, and is of value only to, academically inclined pupils — rather than to the ordinary citizen in his daily life and work. The new approach emphasised highly abstract matters — the common logical structures permeating the foundations of a variety of mathematical topics — as against the earlier approach which guided pupils to mastering everyday mathematical needs. The new topics could be taught to the majority of pupils only at a very elementary level: pupils were taught to recognise a new series of symbols, but the practical purpose of it all was largely beyond their horizon. It was as if they had been taught a new alphabet, but never reached the stage of making sensible words and sentences. (For example, matrix notation is marvellous in solving simultaneous equations in many variables; but merely learning the notation for the transpose of a matrix or the rules for multiplying two matrices, and stopping at that stage, is bound to be seen by most pupils as pointless.)

The new approach thus did not serve the interests of the average child, nor the needs of the average citizen: did it help the specialised mathematician? The answer was given some years ago, correctly in my view, by Dr J. M. Hammersley FRS, of the University of Oxford, in an article in the *Bulletin of the Institution of Mathematics and its Applications.* The title said it all: 'On the enfeeblement of mathematical skills by "Modern Mathematics" and by similar soft intellectual trash in schools and universities'. He saw the new emphasis as 'didactically bad' and, in its extreme form, as 'having blunted the mathematical edge of a whole generation of children to an extent that we do not yet quite realise'.[49]

Some — but only some — of the new topics were subsequently withdrawn from school syllabuses, as if they were fashion items at the end of the season; but the unfortunate consequences for lowered arithmetical competences remain. They were reinforced by the 'discovery and investigative' methods of learning which continue to absorb much time in British schools — but which were hardly seen in the schools we visited on the Continent. For example, English pupils are now required, under the law relating to the National Curriculum, to 'test the validity of statements such as . . . it is harder to get a six on a die than a one'; and to 'observe from data they have collected that woodlice prefer dark, damp conditions because more of them are found under stones, damp rubbish, etc.' These examples, intended for the average 11 year-old, are quoted verbatim from the current version of the National Curriculum in mathematics (revised version laid before Parliament in December 1991; Attainment Target 1: Using and Applying Mathematics, Level 4). Nothing corresponding to these activities was observed in Continental schools visited by the National Institute teams (nor in their syllabuses or textbooks).

The legally-obligatory Statement of Attainment to which these examples relate is expressed in the Statutory Order, very simply, in two words: 'Make generalisations'. If an English pupil is able to 'make generalisations' in this way, neither more nor less, he is to be assessed as having reached Level 4. He is to be down-labelled to Level 3 if he is able only to '*investigate* general statements *by trying out some examples*'; while if he is able to 'make a generalisation *and test it*', he is to be raised to Level 5. Differences between successive Levels, as defined for the National Curriculum, correspond to a two-year difference in the average child's attainments; a child is therefore to be

[49] (1968), pp. 68, 77.

categorised as having attainments corresponding to an average 9, 11 or 13 year-old on the basis of such subtle distinctions in generalising capabilities as judged by his teacher.[50]

A fifth of the total marks in mathematics is now required by the National Curriculum (since its revision in December 1991) to be devoted to this investigative branch of the subject (misleadingly called 'Using and applying mathematics'), just as a fifth is to be devoted equally to each of the other four topics distinguished by the National Curriculum: Arithmetic (called Number in the National Curriculum), Algebra, Geometry (called Shape and Space) and Handling Data. It is surprising that the weightings devoted to these five topics should be equal; and even more surprising that they are equal throughout the age range and throughout the attainment range. It contrasts with widely accepted teaching practices that a child should begin predominantly with arithmetic; and that even at secondary school for those who have difficulty in mathematics, the mastery of arithmetical topics is to be given priority. That remains the approach elsewhere, including the Continental schools we visited. No adaptability in degree of specialisation within the subject formed part of the vision of those who formulated the present National Curriculum for British schools.

In so far as there may previously have been an over-concentration on textbook arithmetical sums devoid of any realistic context, it is understandable that educational reformers should call for more applied teaching. That is to say, in order that pupils should learn the circumstances when a particular technique is to be applied, it is helpful that mathematical questions in school are set in the context of counting apples, dividing cakes, angles of a ladder leaning against the wall, amps and volts, interest on capital, and pressures and volumes of a gas in a container. But this kind of applied example needs to be clearly distinguished from the 'investigation' favoured by the National Curriculum approach, in which much time is spent by pupils collecting data which could just as well be given to them (counting the number of cars passing the school door, working out how the proportion of red cars varies during the day); or pursuing tedious open-ended abstract exercises with no practical significance (for example, which numbers cannot be expressed as the sum of three

[50] A further curiosity is that no intermediate Levels are permitted under the law (corresponding to average 10 or 12 year-olds, i.e. Levels 3½ or 4½).

primes?).[51] In all classes teachers often find it convenient to provide brighter pupils with extension exercises to keep them busy while weaker pupils are being instructed in basics; but in mixed ability classes that need increases, and may reach unjustifiable and unacceptable levels. Such investigational exercises then serve as convenient 'time-fillers' to meet teachers' needs in that situation; it is not clear that they have served any other significant positive instructional purpose.[52]

We see, in short, that the teaching of mathematics in British schools has distinctive elements which have contributed consciously and deliberately to less emphasis on arithmetic — and thus, not surprisingly, to low attainments in that basic branch of mathematics. Many pupils have consequently had difficulties in other branches of mathematics, and in those branches of science that rely on mathematical formulation (physics, in particular). It has put average and below-average school-leavers at a particular disadvantage in their subsequent technical and vocational training.[53] If a very simple first step forward had to be suggested — within the present organisational framework of the National Curriculum in mathematics — it would be broadly this: abolish the present first Attainment Target dealing with investigational methods, and simply add the time saved to arithmetic![54] The precise emphasis on arithmetic should, of course, vary with age and ability level. It is obviously not the only change that I would propose: for

[51] These issues are discussed further by Alison Wolf, 'Testing Investigations', in P. Dowling and R. Noss (eds.), *Mathematics versus the National Curriculum* (Falmer, 1990), esp. pp. 148–50. See also the Cockcroft Report, p. 74. The example on prime numbers derives from a theorem proved, but only partially, by Vinogtador in 1937 (I am indebted to Professor Howson for this information).

[52] 'Undemanding time-filling exercises' of this sort have recently been recognised (in those terms) by HMI as a source of unsatisfactory standards (*The Teaching and Learning of Number in Primary Schools* (Ofsted, HMSO, 1993), p. 3); but HMI have not asked themselves why such 'undemanding' tasks are characteristically set more frequently in British than in Continental schools.

[53] For example, a qualified motor mechanic — as part of his routine work — needs to be able to carry out divisions, such as divide 600 by 0.2, if he is to set the torque correctly on his tools. As we saw on our visits to vocational schools in Britain and the Continent, this kind of calculation is difficult even at age 20 for English final year mechanical students, and consequently leads to intuitive solutions and imprecise work; that calculation was taken in their stride by a corresponding class of vocational pupils on the Continent to whom we set the same exercise, and who had been taught arithmetic at their secondary schools to higher standards.

[54] The time devoted to the fifth Attainment Target, Data Handling, could, in my opinion, also be reduced with advantage. In practice many schools have so far devoted more time to arithmetic than indicated under the National Curriculum; nevertheless, the present official curriculum inhibits higher standards because of the restrictive way it is framed.

example, earlier remedial measures need to be put in place to reduce the proportion of stragglers at early ages; and there need to be changes in teaching styles to ensure that the whole class advances together, as on the Continent, so that the basic minimum for that class is mastered by virtually all pupils. A greater emphasis on arithmetic, while not the whole remedy, would amount to a significant and simple first step towards closing the gap in mathematical attainments between Britain and the Continent; and that, in turn, would contribute to a better foundation for the teaching at school of science and technology.

Let me turn finally to an aspect of schooling not deeply researched nor widely discussed in academic circles: the teaching in secondary schools of practical subjects — such as metalwork, technical drawing, engineering practice, textiles, or commercial practice. (I suspect the main reason such subjects are under an academic cloud is that those who become professors of education attended grammar schools, where such subjects were not taught at O-level.) A substantial proportion of Continental pupils — say, about a third to a half of 14–16 year-olds — follow courses at secondary schools which provide them with a firm grounding in these practical areas, and encourage them to proceed to traineeships leading to recognised vocational qualifications. Because of that practical grounding provided at secondary schools, it is also more advantageous for employers to take them on as trainees.

In secondary schools for non-academic or vocationally-oriented pupils visited by National Institute teams in France, Germany, the Netherlands and Switzerland, pupils of that age concentrate on *applied* aspects of their subject area: they work on relevant raw materials, they learn to use correctly a range of basic tools, and they produce simple finished artefacts of high quality to given designs. The achievement of high *quality* in a narrow area is more valued than breadth of approach at a superficial level. Educationists and employers on the Continent value not only the specific basic occupational skills acquired by pupils in this way, but — perhaps even more — the acquisition of general 'good work habits' (called *Arbeitscharakter* by the Swiss) typified in terms of clean working, precision, perseverance, reliability and responsibility. Educationists also emphasise that many pupils who otherwise would have difficulty in their academic subjects, improve in their academic subjects as a result of understanding acquired 'through their fingers' in practical subjects.[55]

[55] Further details may be found in the paper by Helvia Bierhoff and the present writer in the *NIER* (May 1993).

British secondary schools in the past generation have gradually moved this part of their curriculum towards very different aims. They have aimed for a more intellectualised approach, emphasising general 'problem-solving skills', design and evaluation; pupils' tasks are set in highly generalised contexts (e.g. how to give expression to a celebration), or involve highly over-complex contexts (e.g. redesign an airport — a task set to 14 year-olds!).[56] As part of this approach, the element of actual *making* in practical subjects in British schools has been marginalised — often trivialised into 'cardboard engineering', or so-called 'Blue Peter' technology. Broadly speaking, only an eighth of the total marks for the obligatory subject of Design and Technology in the National Curriculum is to be awarded for actual *making*. It is now hardly possible for average 16 year-old pupils in British schools to develop their practical skills to standards current on the Continent, and previously attained in Britain in those secondary schools where applied specialised subjects were taken at GCSE examinations. Unless practical subjects are intellectualised, and linked to bulky paper-work activities (the so-called 'design-folio'), they have tended to be regarded as not having a wholly legitimate place in the secondary school curriculum in Britain.

The new approach was given its fullest expression in the National Curriculum for Technology issued in March 1990. It soon led to great difficulties. The so-called 'problem-solving' approach requires each pupil to pursue his individual response to a theme or problem specified only in the very broadest terms. In addition, the NC required a great range of materials to be used by each pupil, and a great range of products in a great range of contexts. This led to inadequate specialisation, inadequate progression, and poor quality of finished work; breadth is pursued at the expense of specialised depth and high standards. Inevitably there have been difficulties in teaching the class as a whole and in supervising it. School-leavers in the less academic half of the attainment range have been particularly disadvantaged and demotivated.

A revision of this part of the National Curriculum was ordered by the Secretary of State in the summer of 1992. Proposals resulting from a series of consultations remain under consideration; actual revision of the curriculum is now not expected until 1995. Whatever the eventual outcome, at this stage we have to recognise that this part of British

[56] HMI, *Technology Key Stages 1, 2 and 3* (HMSO, 1992), p. 18.

schooling — combined with poor mathematical attainments at school — has contributed, and continues to contribute, to the difficulties that British school-leavers face in attaining the wider technical competence characteristic of Continental workforces.

In Conclusion

In this lecture I have tried to trace the connections between Britain's economic performance, the vocational training and qualifications of its workforce, pupils' school-leaving attainments (particularly of average and below-average pupils in mathematics and in practical subjects), and recent Government measures to improve the situation — now embedded in the National Curriculum for schools and in a new system for the award of vocational qualifications. The experience (or, should I say, experiments) of the past decade have clearly been far from wholly successful. Nevertheless, hope is in the air. First, there is now a much greater awareness among the public at large of the importance of education and training issues, and of the need for coherent policies for improvement. Secondly, concern with schooling has shifted to the acquisition of knowledge and skills — rather than predominantly with the adequacy of resources or the social divisiveness of the system: there is a greater understanding that the pursuit of pupils' instant happiness is not the over-riding objective of school — but that learning targets need to be set and whole-heartedly pursued, and that learning often needs effort, and can sometimes be a painful process. Thirdly, there are signs of greater concern with economic objectives — a greater pre-vocational emphasis from the age of 14 at schools, and the need to improve vocational training and certification after the age of compulsory schooling.

Much remains to be done. The National Curriculum is now being revised. I hope it will be reduced in scope, focus on the essentials of core subjects to be mastered in each class, and provide more freedom for variation amongst schools — so that parents can choose what is appropriate for their own children, given their abilities and employment opportunities.

I would hope I need not add — but it is safer to do so — that vocational competence is not, in my view, the be-all and end-all of education; but I believe it to be an important part, and one that has been under-emphasised — and at times almost rejected — in British schooling. Preparation for vocational competence is explicitly accepted as one of the prime objectives of schooling on the Continent; and it is recognised as helping very many pupils towards an understanding of the more theoretical and academic aspects of their education which they might otherwise find difficult and reject.

I repeat, much remains to be done. As was said by a moralist of the first century: it is not for us to finish the work, but we are not thereby freed from the duty of participating in it.[57]

Note. This lecture provides me with an opportunity for thanking those responsible for the direction and management of the National Institute for supporting my team's researches in this field over very many years. Our thanks also go to those in the worlds of industry and education — here and abroad — for their co-operation; and my own thanks go to my team and colleagues at the Institute for help in every way, and to them and others for comments on preliminary versions of this lecture. I am glad to acknowledge the financial support provided for our researches by the Economic and Social Research Council, the Gatsby Charitable Foundation, the Anglo-German Foundation for the Study of Industrial Society, and the Leverhulme Trust.

Discussion

In past years the *Proceedings* have contained the text of the Keynes Lecture, without any record of ensuing discussion. This year the Lecturer's chosen topic was one of wide public interest and it was decided to publish comments from three invited discussants (Lord Griffiths,[58] Professor Halsey, and Mr Scott) and any substantial contributions from the floor, along with the Lecturer's response. There proved not to be enough time at the meeting for all those who wished to speak, and several of the following comments were supplied in writing later.

A. H. Halsey, *Nuffield College, Oxford*

I am fond of Sig. He is an authentic political arithmetician in the spirit of William Petty, John Graunt, Samuel Pepys and the founders of the

[57] R. Tarphon, *Ethics of the Fathers* 2:16 (trans. H. Danby, *The Mishnah*, Oxford, 1993, p. 149).
[58] Due to pressure on his time, his contribution was not available in writing before this went to press.

Royal Society in 1662. Their methods flourish in his hands. I am persuaded of his general thesis that British productivity is impeded by deficiencies in education and training. But I won't go on about that: my task is to say what is wrong, not what is right about the argument he offers.

First, his logic is incomplete. He does not offer an explanation, only a correlation — a correlation, that is, between low training and low productivity. You may say this charge is unfair and he certainly suggests useful story lines that would turn correlation into testable explanation. For example, what if the English did produce an equivalent to the German Meister? Would this improve the skills of apprentices? And how much reduction of the productivity gap would ensue compared with, say, an equalisation of wage differentials between skilled workers and trainees in the two countries? These examples both confirm the utility of Sig's empirical method and also show that a very complex set of equations would have to be brought in to a convincing comparative explanation.

Certainly Sig does much better than those who simply assume that expansion of higher education will raise national productivity and then harangue pedagogues to mould the ambitions and attitudes of the young in the required shape. James Murphy has, I believe, disposed of such unhelpfulness (see *Oxford Review of Education*, vol. 19, no. 1, 1993). Sig Prais gives us, by contrast, serious empirical study.

Secondly, his history is not all it might be. I believe he has read Adam Smith too hurriedly. Smith was concerned to condemn fathers who sent their sons abroad (claiming that the resultant idleness and ignorance made them unfit for disciplined labour). Smith then went on to praise the public provision of schools:

> If, in those little schools, the books by which the children are taught to read, were a little more instructive than they commonly are; and if, instead of a little smattering of Latin, which the children of the common people are sometimes taught there, and which can scarce ever be of any use to them, they were instructed in the elementary parts of geometry and mechanics; the literary education of this rank of people would, perhaps, be as complete as can be. There is scarce a common trade, which does not afford some opportunities of applying to it the principles of geometry and mechanics, and which would not, therefore, gradually exercise and improve the common people in those principles, the necessary introduction to the most sublime, as well as the most useful sciences.
>
> The public can encourage the acquisition of those most essential parts of education, by giving small premiums, and little badges of distinction, to the

> children of the common people who excel in them. The public can impose upon almost the whole body of the people the necessity of acquiring the most essential parts of education, by obliging every man to undergo an examination or probation in them, before he can obtain the freedom in any corporation, or be allowed to set up any trade, either in a village or town corporate.

In any case, Adam Smith's conception of the division of labour was Fordist or pre-Fordist. Sig is, of course, post-Fordist and therefore one who puts tremendous emphasis on vocational training. He refers to Alfred Marshall but not to Marshall's treatment of the self-same question as Sig addresses, i.e. the explanation of low productivity. I refer here to Marshall's paper of 1873 'The Future of the Working Classes'. Marshall, we should note, was as much concerned with the social distribution of dignity and citizenship as with productivity. But he did prophesy the transformation of the economy from low skill, low pay and long hours to high skill, high pay and short hours and, as with Sig, the key was educational reform.

But we should note the difference that Marshall was sceptical about the capacity of schools to deliver the appropriate curriculum. Marshall was struck by the fact that Mrs, not John Stuart, Mill had written the chapter in *Political Economy* on 'the Future of the Labouring Classes'. He (Marshall) did not pick up Adam Smith's point that the education of eighteenth-century women was totally focused on what would be useful to them in their careers as wives and mothers. The question of the locus as distinct from the focus of a vocational training is omitted by all these authorities (Smith, Marshall and Prais), but remains vital.

Finally, I would commend to Sig the nobility of Marshall's formulation. He wanted to be rid forever of the working class and he defined class as an effect of work on people, not the other way round. Culture and character were what mattered and working conditions determined them. So no job was to be allowed to exist that tended to make the worker anything but a gentleman. Marshall thought this would mean a wealthy gentleman. Our subsequent national experience suggests the possibility that at best we may be becoming affluent proletarians. The prize for effective solution of Sig's age-old problem remains the possibility of Marshall's New Jerusalem.

M. FG. Scott, *Nuffield College, Oxford; Fellow of the Academy*

Prais argues that, by comparison with other European countries, deficiencies in the training and education of a very large proportion of our young people reduce their productivity. He has shown this in several different ways: there are the conclusions of past studies, there is the relatively high proportion in Britain of those with no qualifications beyond compulsory schooling, there are comparisons of productivity in matched British and Continental enterprises, there is the comparative performance in international mathematical and other tests, and there are the visits to schools here and on the Continent. I find it impossible to resist the impact of so many shots coming from different directions and all landing on the same target. The conclusion is that, if we could only train our young people better, their productivity would be higher and the country would be richer.

How much richer? Prais does not venture an estimate, and nor shall I. I feel obliged, all the same, to draw attention to some rather surprising estimates of productivity in different countries recently published by Maddison.[59] Since he has devoted a large part of his life to assembling this type of statistic, his estimates cannot be lightly dismissed. 1987 is the latest year for which figures for several countries are given. What is being compared is GDP per man-hour worked, with GDP measured, not by converting estimates in national currencies at ruling exchange rates (as is often done) but by the use of purchasing power comparisons. Maddison has used US prices in 1985 as the basis of his comparisons. In principle, the quantity of each item of final expenditure in the 1987 GDP (consumption and investment, both public and private) has been multiplied by the same US price in each country in order to arrive at comparable totals in US dollars. These totals are then divided by estimates of total man-hours worked in 1987 to give output per man-hour. Taking the UK as 100, France is 117, Germany is 99, the Netherlands is 115, Japan is 76 and the USA is 125. Perhaps the most surprising figure here is the German one, which is for Western Germany only.

These figures become even more surprising when taken in conjunction with Maddison's estimates of fixed, non-residential capital stock per man-hour in 1987, again measured at 1985 US prices.[60] With UK 100, we have France 141, Germany 151, the Netherlands 158, Japan 110, and the USA 142.

[59] A. Maddison, *Dynamic Forces in Capitalist Development: A Long-run Comparative View* (Oxford, 1991).
[60] A. Maddison, 'Standardised Estimates of Fixed Capital Stock: A Six Country Comparison', *Innovazione e Materie Prime* (Feruzzi Montedison Group, Milan, April 1993).

Thus, according to these estimates, Germany produced no more output per man-hour in 1987 than did the UK despite having 51 per cent more capital per man-hour, Japan produced about a quarter less output with 10 per cent more capital, and the higher output of the Netherlands, though not those of France and the USA, could be wholly explained by the higher capital per man-hour if one believed in a Cobb-Douglas production function — which God forbid!

Of course there are ambiguities and doubts about these figures. Different prices and different years make German output look relatively better[61] and productivity there may in any case be depressed by the very large numbers of non-German workers who have not benefited from German education. The figures give one pause, but they do not undermine Prais' argument, which rests on more secure micro-foundations, and the variety of evidence I referred to.

Both that argument, and Maddison's estimates, refer to comparative *levels* of output. What are the implications for comparative *rates of growth* of output? Of course, anything which can be done to improve the level of output will inevitably take time to exert its full effect, and so will increase the rate of growth over that limited period. Is there any reason to expect the rate of growth of output to be increased over a much longer period? Since the deficiencies to which Prais draws attention are not so much in higher education (where there is only some doubt about the numbers qualifying in engineering and technology), it seems to me that one would not expect that putting them right would do much to improve investment decisions, or result in greatly superior inventiveness. However, there do seem to me to be at least two ways in which Prais Reform, if I may call it that, *would* affect investment and growth.

I never tire of repeating that investment is the cost of changing economic arrangements. Anything which reduces that cost should promote investment, and, by increasing both its quantity and its effectiveness, should thereby increase the rate of growth. Prais gives an example himself of how this might work out when he describes how, with more highly trained sewing-machine operatives producing women's clothes in Germany, full operating speed on a new style could be reached in three days, whereas in Britain it would take three weeks. Producing new goods is one of the outcomes of investment, and an important aspect of economic growth. So also is adapting to new methods of

[61] See, e.g. OECD, *National Accounts: Main Aggregates Vol. 1, 1960–1990* (Paris, 1992).

production of old goods. If better training shortens the learning time, it must surely reduce the cost, increase the return, and encourage the volume, of both kinds of investment, and thereby speed up economic growth.

The second way in which Prais Reform would raise the return to investment and promote growth is by improving maintenance and reducing breakdown time, since this would increase the rate of utilisation of machinery and equipment.

In conclusion, I would like to take quite a different tack which still drives me along in support of the Prais Reforms. There are many studies which cast doubt on the importance of further additions to wealth as a source of additional happiness, once one has achieved the reasonably prosperous levels which most people already have in North America and much of Europe including Britain.[62] People want more money, it is true, and getting it may initially make them feel happier, but it is doubtful whether their long-term happiness is much affected. Why, then, should we concern ourselves with improvements in education and training? One possible justification is the need to maintain technical superiority in defence. Another is work satisfaction. The same studies which cast doubt on the importance of extra income as a source of extra happiness point to the importance of work satisfaction. Acquiring skills in which one can take pride is one important way of obtaining that.

Jason Tarsh, *Economic Adviser, Department for Education (but speaking entirely in a personal capacity)*

Thinking first about what Mr Scott has just said, I think it is important to try and measure or at least judge what would be the macroeconomic effects of Professor Prais' proposals. The Maddison work (quoted by Scott) is sobering and I was sorry that Mr Scott, having quoted Maddison apparently approvingly, was then inclined to discount those results in favour of the micro evidence. I hold no particular brief for Maddison but the general and important point is that it is not possible to intuit what the macroeconomic gains might be. Indeed there is a view that it really takes a very major change materially to affect the growth

[62] See, e.g. M. Argyle, *The Psychology of Happiness* (Routledge, London and New York, 1987) and R. E. Lane, *The Market Experience* (Cambridge, 1991).

rate — there is the analogy with a supertanker moving sedately through the fiercest winds and waves.

I think a danger with Professor Prais' analysis is that it can reduce to the proposition that if only the population could be better at mental arithmetic then we would all be much better off. That is just not convincing. Related to this, the economic interpretation of Professor Prais' analysis would seem to be that there is market failure. It would be better for all of us, employers, workers, consumers, etc. if we had more of the skills that Professor Prais identifies. The question is: what is stopping people acquiring these skills now and why does the market not signal their value in terms of higher pay and better careers? Where is the army of private teachers offering remedial arithmetic tuition that we would expect to see?

James Murphy, *Department of Educational Research, University of Lancaster*

Professor Prais — at the risk of sounding like an overly territorial educationist, might I ask why, as an economist, looking at an essentially economic matter — national productivity — you assume that the causes of the UK's rather poor productivity record are to be found in the deficiencies of its educational system?

I put this question for two reasons. Firstly, there is, strictly speaking, no 'a priori' reason for assuming a link between education and the economy, particularly at the level of specificity you suggest — e.g., mathematical attainment. Yet, your analysis offers no justification or explanation for such a central presumption. Secondly, there is much in your paper which suggests that such an assumption is unsafe:

1 It does not seem to fit the US; Tables 2 and 3 in your 'summary' reveal that the US falls well behind all other countries cited, in terms of educational attainment. However the US on most estimates of productivity, emerges as having the highest overall productivity of all countries — including Japan.

2 The critical examples relating to 'down time' in the UK and continental factories are open to other explanations other than simply 'educational' deficiency — poor management and poor industrial training practices in the UK, come to mind as possible alternative explanations. Your analysis made little attempt to contain such rival interpretations.

3 Finally, the Japanese educational system is, as you point out elsewhere, exemplary in its efficiency. However the productivity of Japanese industry, as the recent McKinsey study reveals, varies dramatically from sector to sector. Given the assumption of your paper, the problem arises as how the same educational system turns out possibly the world's most productive workers — when at Toyota — and some of the least productive operatives when employed in the textile and food industry.

R. G. Luxton, *Principal Inspector, London Borough of Barking and Dagenham*

An important strand of Professor Prais' lecture was the identification of ways in which our educational arrangements fail those of average and below average academic ability. As Principal Inspector of Schools for the London Borough of Barking and Dagenham the low achievement of the less academic is a constant and central problem. The opportunity to join Professor Prais on his research visits to the Continent, to the Netherlands, Germany and Switzerland, studying at first hand the differences in education in a large number of classrooms, has been of great value. A substantial number of classroom teachers and headteachers (over 40) have now been to the Continent over the past three years to see for themselves. We have also benefited from the observations of German and Swiss teachers and college principals invited to the borough's schools to offer constructive criticism.

The observations and conclusions of our teachers support all the findings of Professor Prais. They have helped us to identify three particular differences between Britain and our near neighbours which impinge directly on the low achievement of the less academic. We believe action in these areas would bring marked improvements not only in Barking and Dagenham but much more widely.

The first difference is the attitude towards achievement in German, Swiss and Dutch schools as compared to that in Britain. Basic minimum standards in language, in arithmetic, in practical work are set for *all* to attain. Instructional time and resources are used to bring all pupils to an acceptable level of achievement. If necessary pupils are given additional time to reach minimum standards — on occasions, by repeating a year. In England, every pupil has the same amount of teaching time and moves on to the next year whatever his or her level of achievement. The 10 levels of attainment associated with the National

Curriculum reflects the English concern to differentiate pupils rather than ensuring minimum standards for all. It is only to be expected that more Continental pupils reach satisfactory minimum standards than here.

The second difference is in teaching method. Teachers on the Continent consistently use a rich and varied form of direct instruction. Lessons have a regular form, pace, rhythm and length. The shape of a lesson can be predicted before visiting a classroom. This does not make for dullness as teachers in England, taught to value unpredictability, spontaneity, group work or activity based methods of learning, often suppose. Their views alter when they note the quality of explanation, of questioning, of involvement in the German or Swiss classroom. The research of the past 20 years, revealing in particular the benefits which younger and slower students receive from direct instruction, fits well with Continental practice. It is little known or understood in this country. Here, the very pupils, the less academic, who have most to gain from direct instruction are least likely to receive it.

The third difference is the provision of well defined vocational and technical pathways in addition to the academic pathway in secondary education. They do not attempt a unified qualification as seems to be in vogue in certain circles at present in Britain. Qualifications stand on their merits. General subjects retain their independence and are linked to pupils' practical work and vocational preparation. Vocational guidance is precise and specific. And, most important of all, the standard of achievement, especially of the less academic is higher — achievement in classroom lessons, in homework, in exercise books, and in the acquisition of appropriate qualifications.

Direct observation in classrooms amply confirms the statistical and other findings presented by Professor Prais this evening.

Geoffrey Howson, *University of Southampton*

Professor Prais has drawn attention to some of the problems of mathematics education in England. In particular, he has emphasised a lack of attainment by, and of expectations of, average and below average students, and has criticised the current National Curriculum which presupposes an unacceptably large degree of variability in student attainment and fails to set appropriate motivational and attainable goals for adolescents in the lower two-thirds of the ability range. Indeed, Professor Prais underestimated the seriousness of the situation by suggesting that all was well with the most able. Since 1984 the numbers attempting mathematics A-level have fallen by about 40 per cent; even worse, there has also been a fall in the proportion of the age cohort seeking this qualification, and this at a time when the proportion of 16 year-olds staying on at school has risen. This is already having serious effects on recruitment to engineering courses, to which, as indicated, we need to attract more students. Much, then, needs to be done within mathematics education and there are no simple solutions. (It must be stressed, however, that not all is black, and none of our 'rival' countries is without problems.)

Yet the link between mathematical competence and economic performance is not merely one of cause and effect. I suspect that a comparative study of attainment in a second language would provide very similar correlations to those Professor Prais presents. Does the arithmetical competence he cites bring with it economic success, or is it just another symptom of ambitious, hard-working, socially stable societies which take education seriously? Have the Swiss and Germans succeeded, not because they can calculate 5634.3 – 3194.02 + 457.6 + 378.98 – 856.75, an example I cannot imagine occurring in practice, but because they have subjected themselves to the discipline and associated effort needed to acquire such techniques? It is right to draw attention to weaknesses in mathematics, but I suspect the root of the problem lies outside our mathematics classrooms — imperfect though many of these may be.

Anthony Tomei, *Nuffield Foundation (speaking in a personal capacity)*

Professor Prais' studies of the deficiencies of vocational education and training in the UK have had an important influence on the long overdue reforms which are now occurring and for that we are greatly in his debt.

His analysis of the performance of English schoolchildren in mathematics is less persuasive, however. No one would deny the three main points of the argument. The standard of achievement in mathematics of children in our schools is too low; it is the performance of children of below average ability which gives most cause for concern; and arithmetic is our weakest area relative to other countries. But the international comparison data on which these analyses must rest in the absence of rigorous fieldwork must be interpreted with caution (as the authors frequently remind us). The picture may be less clear cut than Prais suggests. Consider the results of the last IAEP survey (to which Prais makes reference).[63] Of the 14 European and North American countries in the survey 10 had average scores in the range of 55–64 per cent. (The others were Switzerland (71 per cent), Soviet Union (70 per cent), Hungary (68 per cent) and Portugal (48 per cent). England's score was 61 per cent, (or 59.5 per cent using Prais' adjusted figure), which is around the average for this group. Moreover, the range of performance across those countries (i.e. the difference between the performance of those at the 5th percentile and those at the 95th percentile) seems remarkably constant. There is a similar picture in science, where the UK does rather better.

One-third of the IAEP questions were on arithmetical topics whereas only one of the five (equally weighted) areas of the English National Curriculum concerns arithmetic. Given that arithmetic is our weakest area this tends to depress our relative standing overall. Conversely, Prais dismisses rather lightly our better performance in other areas, especially data handling and geometry, where the UK's relative advantage is not only significant but consistently so.[64]

Nor is it clear that the comparison data have much to reveal about the causes of the admittedly poor performance of English children in arithmetic. On the likely effects of the use of calculators, for example, the IAEP data show no discernible pattern. The researchers say:

> The liberal policy of schools on calculator use is sometimes blamed for a lack of numeracy skills among pupils in Britain, but despite the evident relative weaknesses of England in this area, pupils reporting more experience with calculators had higher scores overall than those with less experience. But there is no evidence for a causal link in the IAEP results.[65]

They also say:

> There were no indications that, within each country, those schools which banned calculators did any better on the mathematics test than those which permitted them.[66]

Similarly, from the evidence presented it is hard to support the suggestion that 'modern mathematics' must bear responsibility for our

[63] A. E. Lapointe, N. A. Mead and J. M. Askew, *Learning Mathematics* (Educational Testing Source, Princeton NJ, 1992), Summary table, p. 16.
[64] D. Foxman, *Learning Mathematics and Science: The Second International Assessment of Mathematics and Science in England* (NFER, 1992), p. 13.
[65] Ibid. p. 70.
[66] Ibid. p. 55.

poor performance in mathematics. Our pupils performed no better in the IEA survey of 1963, (cited by Prais), which predates the introduction of 'modern mathematics'. Moreover the methods of 'modern mathematics' are by no means confined to the UK but are widely used internationally.

The search for explanations might lead towards other equally plausible suggestions. The Swiss, for example, have nearly 30 per cent more maths instruction per week than their English counterparts (251 minutes as against 190) and their class sizes were 20 per cent smaller (18 as against 22). But then again class sizes in Korea, which outperformed all other countries, are enormous (49) and they have only 179 minutes of instruction per week.[67] As the IAEP researchers remind us:

> . . . little can be deduced about the link between performance and background variables in surveys such as this because the relationships are correlational rather than causal.[68]

Professor Prais subsequently replied in writing:

May I add some words of clarification in response to discussants' comments? I agree of course with Professor Halsey that there is more to be gained from raising general educational standards than improved economic performance: there is always the over-riding aim — as Marshall put it — of increasing the numbers who will have 'the opportunity of living a noble life'. But I also have little doubt that Britain's ability to survive in international competition today, when technology is advancing so rapidly, requires substantially higher educational and vocational standards *for a substantially greater cross-section of the workforce* than so far attained. To those who still believe that there is little more than accidental correlation — and little causative connection — between the education and training of a country and its economic prosperity, I can only suggest that they proceed as we did: namely, that they first observe the differences in production organisation and efficiency in British and Continental firms; and then ask production and personnel managers in this country of their problems in organising efficient production. Our researches at the National Institute have explicitly involved 'fieldwork' of this sort, going beyond simplistic

[67] Lapointe *et al.*, Summary table, p. 16 and figure 5.2, p. 79.
[68] Foxman, p. 70.

comparisons of statistics of average years of schooling in different countries, irrespective of the mix and quality of what has been learnt.

Mr Tarsh expressed a view of long standing amongst the educational establishment in this country doubting the importance of numeracy: could more mental arithmetic in schools make that much difference? No one disputes, in broad terms, that literacy and numeracy are the twin foundations of education; but unless the foundations of numeracy are solidly laid in schools, in such a way that virtually all pupils are proficient in 'basics', I fear we shall continue to have an unnecessarily large proportion of our school-leavers unable to undertake training for skilled employment. I say this on the basis of mathematical standards attained in Continental primary and secondary schools, and in their vocational colleges, by pupils of average and below-average schooling attainments. Automated technology in modern industrial economies has replaced large numbers of unskilled workers by production methods requiring tighter tolerances, greater precision, and the ability of all involved to think numerically (as I said in my lecture, the days of the unthinking 'Fordist' operative are over).

Continental educationists, as those of Japan, continue to place much greater emphasis on the mastery of arithmetical basics at school, and limit the use of calculators; they have not done so unthinkingly, nor without having in mind the employment prospects of their pupils. I fear that those who have laid down the details of the National Curriculum in mathematics for our schools have been too impractically visionary.

I agree with Professor Howson that greater effort and application are to be seen in Continental schools, in contrast to the demotivation of pupils at ages 14–16 apparent in many of our schools. Our inadequately differentiated curricula — inadequately focused on the *attainable* needs of average and below-average pupils — I would suggest, have a great responsibility. Parents' lack of choice amongst schools offering different curricular mixes, and with different pre-vocational specialisations, remains the missing market-element, as Professor Lord Griffiths emphasised in his contribution and for which Mr Tarsh seemed to be hunting in his comment.[69]

Mr Tomei of the Nuffield Foundation, speaking in a personal

[69] Professor Lord Griffiths spoke *inter alia* on the need for parents to be able to exercise their choice between schools providing alternative types of teaching and curricula, and of the need for clearer information on what is provided by schools.

capacity, doubts whether Britain's poor schooling performance in mathematics is as 'clear cut' as my lecture suggests.

Experienced school inspectors and headteachers from Britain, together with Continental educationists on cross-visits, all concurred in our joint assessments of standards reached in our schools; the assessments were based on systematic classroom observation of lessons, pupils' written work, and discussions with local teachers and educationists. These findings in all respects conformed with the results of the IEA and IAEP international tests of pupils' attainments mentioned in my lecture.

Of course, the results of the large-scale international tests of pupils' attainments that have been carried out by IEA and IAEP need to be interpreted carefully if valid clues are to be derived that are relevant to Britain's educational problems; I mentioned certain caveats in my lecture and, in responding to Mr Tomei, need refer to them again only briefly here. First, the co-operation of Britain's schools in that inquiry was low; weaker classes are more likely to refuse co-operation, and one must therefore suspect serious upward biases in the published average scores for Britain. In other words, the true attainments of Britain's pupils are likely to be worse than shown by the published figures. Secondly, comparisons of British pupils need to be made with other *advanced* countries and not, as Mr Tomei does, with a mix of countries some of which are still in a developing phase. Thirdly, since Britain's top pupils do well, its educational problems are disguised if we look at the *average* scores of pupils; we need to look at pupils lower down the scale, say, those at the lowest quarter or lowest tenth. IAEP's published scores for the lowest tenth are shown in Table 3 of my paper, and are indicative of the scale of the problem. The central lesson I drew in my lecture from this and other surveys was that Britain has approximately 2–3 times as many low attaining pupils as other advanced countries (defined in terms of scores reached by the lowest tenth in other advanced countries). Deficiencies of this order of magnitude have fundamental consequences for subsequent vocational training, for youth unemployment, and for the productivity of the economy.

The interpretation of survey results on the use of calculators, even within a single country, requires great care. A well known analogous example, which illustrates the difficulties well, is the repeated finding in surveys of schooling attainments that pupils in larger classes show higher average test-scores than pupils in smaller classes. A moment's reflection is sufficient to remind us that, where a school has parallel classes, it is sensible to put weaker pupils into a smaller class; and this is probably the main reason why surveys find that larger classes, on average, show better performance. It obviously does not follow that the country would do well to increase class sizes for all pupils. Similarly, if pupils within a country who are better in mathematics are shown by a survey to use calculators more frequently, it does not follow that a greater use of calculators by all pupils would raise attainments. Mr Tomei does not quite say this; his quotations are all phrased negatively ('there is no evidence . . .') but, I fear, a quick reader might think this was his view. Our research teams were much impressed by the priority given to mental arithmetic over written arithmetic in Continental primary schools; consistent with that priority — and in contrast with our present practice in Britain — was the absence of pocket calculators until the age of about 14.

I agree with Mr Tomei that Britain's problems in school mathematics precede 'modern mathematics'; but I hope he agrees that the latter's introduction has far from helped the resolution of these problems. Unfortunately, he does not distinguish the new *topics* introduced by 'modern mathematics' (set theory, algebraic structures, probability . . .) from the new *pedagogical methods* (individualistic rather than whole-class teaching, investigative methods . . .). The former were indeed introduced in many countries, have since been moderated, and were hardly evident in our recent visits abroad. It is the strong rise in Britain of the new pedagogy, with its time-consuming investigative methods (Attainment Target 1 in our National Curriculum), which continues to impose a particularly great burden on our school time; these methods were of no significance in current practice in the Continental schools we observed. On the need, nevertheless, to increase total school time devoted to mathematics in this country, I am glad to agree with Mr Tomei (I believe one 45-minute period every day should be adequate; 70-minute 'double periods' taught on only three days a week — as sometimes found in our schools — are not as effective). In comparison with other countries it needs to be remembered that Britain begins compulsory schooling rather early (in relation to Switzerland — two years earlier!), and the contrast in *total* school time spent on mathematics during compulsory schooling is not as great as Mr Tomei implies.

In any event, it is good to know that Mr Tomei agrees on what he calls my 'three main points': the standard of school mathematics is too low in this country; children of below-average ability suffer most; and arithmetic is our weakest area within mathematics (for our supposed superiority in other branches of mathematics, he needs to look more carefully at note 46 in my lecture).

I conclude with some technical observations on the aggregate estimates of GNP per head, mentioned by Maurice Scott. As he recognises, these figures — apparently putting Britain and Germany on a par — are unrealistic; they conflict *inter alia* with the Institute's detailed industrial observations on comparative productivity. Nor do they reflect the declining manufacturing base of this country, its technological inadequacies and lack of product reliability. More research on the basis of such aggregate statistics is necessary; perhaps two problems may be mentioned here as warranting attention. First, issues connected with quality-matching have not been adequately overcome in the associated comparisons of purchasing power equivalences used to convert the money values of GNP in different countries (consequently understating the real GNP of countries which tend to specialise in high quality products, such as Germany or Switzerland). Secondly, there remain fundamental difficulties in comparing the real output of services (e.g. education); inputs (e.g. numbers of years of schooling) are often used in these comparisons as indicators of output, so eliminating any measured productivity difference in these sectors. The result is that it is likely to be an understatement of international differences in productivity for the economy as a whole, and of differences in standards of living.