AC 2011-634: HIGHER TECHNOLOGICAL EDUCATION IN ENGLAND AND WALES BETWEEN 1955 AND 1966. THE CONTRIBUTION OF THE BRITISH ELECTRICAL ENGINEERING INDUSTRY TO ITS DEVELOPMENT

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Developments in Higher Technological Education in England and Wales between 1955 and 1966. The Contribution of the British Electrical Engineering Industry.

Introduction; toward restructuring higher technological education in the nineteen fifties

Within the United Kingdom there are four jurisdictions. These are England, Northern Ireland, Scotland and Wales. The education system in Scotland differs to the other three which operate similar systems. This paper relates to key developments in higher and third level education that took place between 1955 and 1966 in England and Wales. The term higher is taken to mean degree or degree equivalent education. In this paper it includes qualifications that correspond to a technology degree in the United States (Higher National Certificates and Diplomas). All other courses are defined as third level. The higher education level embraced a university sector (private) and a public sector funded primarily by Local Education Authorities (LEA's). It is with developments in higher education in the public sector that this paper is concerned.

At that time the education system in England and Wales was highly selective. A simplified model of the system is shown in exhibit 1. After primary school the student was directed to one of three types of school. The majority of children went to secondary modern schools as there were only a relatively small number of technical schools (*circa* 200). They left secondary modern schools at the age of fifteen for the world of work and possibly the further education system. Their employers may have allowed them to have one day off per week to study at a local technical college. If not their only recourse to study was in the evenings. Very often day release courses were accompanied by evening programmes. Every conceivable course was available in the public sector from the provision of programmes for operatives at one end of the spectrum and courses for degrees of the University of London at its other end (see below). Most of these courses were for part-time study. Children in grammar schools, about 20% of the age group, continued their education until they were sixteen. At that time they took an examination in each of the subjects they studied called the Ordinary Level of the General Certificate of Education (GCE 'O' Level). The results of this examination were used to determine their suitability for a further two years in the "sixth form" in school with the intention of seeking a place at university. At the end of this programme they took an examination in each of the subjects studied called the Advanced Level of the General Certificate of Education (GCE 'A' Level). To enter a university the student was required to meet the matriculation requirements of the university they wished to attend. This was obtained by exemption if they had passed subjects in the General Certificate of Education. The minimum requirements for matriculation were agreed to be three 'A' levels and one 'O' level, or two 'A' levels and three 'O' levels. In practice these examinations were graded and university departments generally demanded much more than the minimum requirements. Students would be expected to obtain C grades or better in at least three subjects at 'A' level and

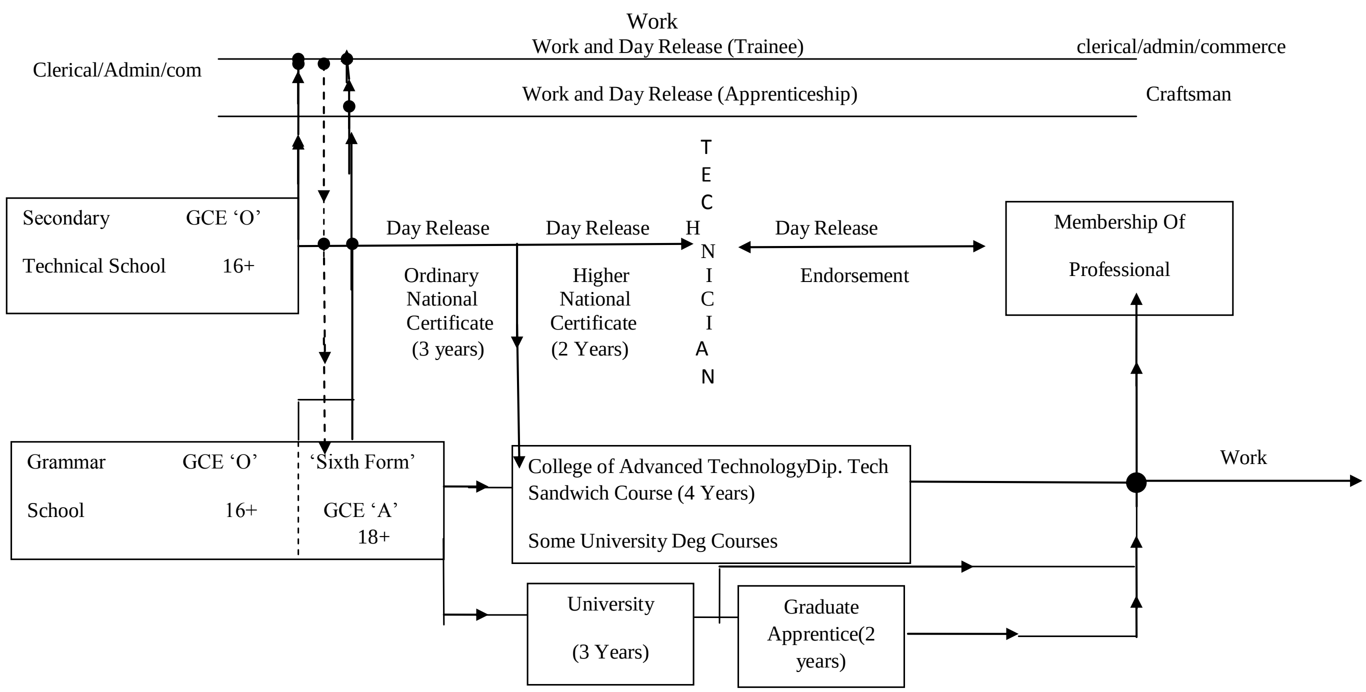

Exhibit 1. Very Simplified Model of the System of Further And Higher Technological Education in England and Wales Circa 1956. Supported by a system of Regional (technologist/ technician courses), Area (technician courses), and Local (craft, trade, operative courses) technical colleges.

to have passed 5 or more 'O' levels. The 'Oxbridge' Universities could demand 3 grade A's at 'A' level. The 'A' level examination was considered to be at least the equivalent of the first of a four year programme in the United States and other countries offering similar courses. It was the A level that the Thatcher government called the 'gold standard' of English education. The "sixth form" was called the jewel in the crown of secondary education. "Form" is the British term for the American "grade." " *Its curriculum and, especially, its method of work, provide a bridge between the relatively set classroom instruction of the 'main school course' and the specialization and independent study demanded in the university*." So wrote Payne who suggested that it "*might be called a post-graduate secondary school*." [1,p131].

Payne cites US Admiral Rickover who said "*Most of the liberal arts education given in our liberal arts colleges has been absorbed into the curriculum of the European academic secondary schools…*"[1.p132]. It was an attitude that had important consequences for beliefs about the role of the university in liberal education. Another consequence of this specialization was that it enabled the three year bachelor's degree to be the equivalent of an American master's degree [1.p 133]

Payne notes that if the purpose of the grammar school system was to enable its students to go to university then it had been singularly disappointing [p144]. Only a quarter completed all the stages for university entrance and that represented about 6% of all pupils in the public school system in a particular cohort. It was assumed that only the top 9% of the intelligence range would be able to earn an honours degree but the output from the schools was about 40% short of this total. There was much concern with "early leaving" a topic that was the subject of two major reports.

By 1956 a few students in the secondary modern schools were taking 'O' levels, and if successful could transfer to a sixth form in a grammar school.

The diagram excludes a small number of direct-grant schools so called because they were funded directly by the State and not the LEA's. At the time they would have been considered to be elite grammar schools. The diagram also excludes the inappropriately named 'public schools' which are in reality independent fee paying private schools.

For those leaving school at fifteen or sixteen and wishing to do some kind of engineering or applied science the major route was via a National Certificate completed by part-time study. The Ordinary National Certificate (ONC) was completed after three years and considered to be the equivalent of 'A' level although it was held to be light in mathematics. It would be regarded as a junior technician qualification. A further two years would complete the requirements for a Higher National Certificate (HNC). It would be regarded as a higher technician qualification. But the student could continue and take further courses called endorsements. These were required for membership of the professional institutions. The Burnham Committee on teachers pay had the task of evaluating the wide range of higher education qualifications for their equivalence to a university degree as teachers received merit payments for the possession of a degree. Membership of the professional institution obtained via an HNC with endorsements was considered to be the equivalent of a general degree as opposed to an honours degree for the purpose of this payment. Hence the significance of the letters A.M. I.E.E. and A.M.I. Mech.E after a person's name. The professional institutions had Royal Charters that enabled them to set their own examinations. The HNC and endorsements were regarded as an equivalent qualification for entry to a professional institution, and the Institutions played a role with the Ministry of Education the examinations and their assessment for the national certificates. Many technical colleges were, therefore, doing equivalent degree level work by part-time study and some full-time study. Moreover, in 1957 more persons with national certificate qualifications were admitted to Associate Membership of the thirteen recognised engineering institutions than persons with university degrees (table 1). But some of those with university degrees would have earned them by study in public sector institutions as explained below. In all cases persons seeking associate membership or its equivalent would have had to have had several years of approved experience in industry.

Table 1. Qualifications for exemption offered by new associate members of professional institutions (1957). Extracted from Payne [1. p 215] and supplied to him by The Lord President of the Council.

Institution	Total	Univ. deg	Assoc	HNC	Other	No exemption
Royal Aeronautical Society	340	145	8	62	125	
Chemical Engineers	129	105	1	7	8	8
Civil Engineers	807	602	8	66		131
Electrical Engineers+	937	443	22	393	79	
Gas Engineers	69	10		31	27	1
Marine Engineers	411	21			390	
Mechanical Engineers	1614	290	10	1129	185	
Metallurgists	179	91	4		33	51
Mining and Metallurgy	72	42	25		5	
Municipal engineers	128	31	2	5	14	76
Naval Architects	130	29	3	36	62	
Production Engineers	406	21		303	82	
Structural Engineers	322	70	12	25	78	187
Totals	**5544**	**1900**	**95**	**2057**	**1038**	**454**

The further education system as the public sector was known was extremely complex. As Venables wrote "*There is no such thing as an average or typical "further education establishment," or even- to choose a narrower field-typical technical college*." [1.pp 8 -10 & 5]. Suffice it to say that of the 592 institutions in the sector a small number of polytechnics and technical colleges were able to offer programmes for university degrees primarily of the University of London. Table 2 is Payne's estimate of the awards from advanced courses in the further education sector in technology for 1957 [1.p242]. External degrees of London University were obtained by sitting examinations set by the University of London courses for which could be offered by technical colleges. In a few of these colleges (13 in all) among the staff were teachers recognised by the University who participated in the procedures for setting examinations and assessment. Successful candidates from these institutions were awarded an internal degree of the university. A small number of degrees were awarded by other universities but Payne had no data on which to base an estimate. A few colleges awarded degree equivalent associate diplomas. But many of those completing higher level courses did not go on to become technologists and remained at the higher technician level.

About half the output of qualified engineers achieved that goal through part time education. Their attendance on day-release courses was dependent on the good will of their employers. Many firms some of them small and medium sized had well developed apprenticeship schemes that also provided practical training at work. To some extent industry and the further education sector were interdependent.

TABLE 2. Payne's [1. p242] estimate of the number of advanced courses in technical colleges in 1957.

Type of Advanced qualification	No. of courses offered
London internal degrees	394
London External degrees	694
Higher National Diplomas	489
Higher National Certificates	8796
College Associateships	106
Other awards	648
Total	**11, 127**

Over the years many of the large firms in the UK, and some medium sized and a few small ones had developed attested training schemes that were characterised by variety. Companies would offer craft apprenticeships for school leavers wanting to become skilled tradesmen. Some would be allowed to advance to Ordinary and Higher National Certificates for technicians. In addition they might offer a range of student apprenticeships from those that involved three to five years part-time study and work for the associate membership of an institution to three years study at a university with fees paid and work provided in vacations with often a year's practical work before entry to university. Finally, many companies offered apprenticeships of two years duration for university graduates. Company's placed graduates in different parts of the organization for short periods in order to provide them with a wide range of experience and establish if they had any special skills or aptitudes. Some of these apprenticeships were prized, as for example those offered by Rolls Royce. The importance of industry in training for all levels of industrial work, but especially technicians and craftsman is illustrated by the fact that in 1955/56- 369, 251 students were released for college study during working hours. Of these 61% were under the age of eighteen although 13% were over the age of 21, which in the following year increased to 15% [1.pp322/323]

This was the picture in 1955 when the Government decided to restructure technical education in response to a belief that there was both a shortage of qualified technologists and a gap in the training of those preparing for such work in industry.

1955-The National Council for Technological Awards [1, 6, 9]

In 1945 A Committee of the Privy Council (The Percy Committee) reported on the future development of Higher Technological Education in England and Wales [7]. The Committee distinguished between engineer scientists on the one hand and on the other hand engineer managers (design, manufacture, operation and sales). It argued that the responsibility for training the first group belonged to the universities and for the second group to the technical colleges. The Committee criticised day release and evening study because it gave too little attention to the fundamental sciences in the earlier stages. It not only thought that 1500 engineers per annum should be trained to the highest level in the technical colleges but that the aggregate length of the academic course should be the same as that of a university programme, and that it should be interwoven with a planned course of works practice. The sandwich (cooperative) courses that emerged were a refinement of this principle and occupied four years of interwoven academic study and work experience.

1000 of the 1500 would be educated via the higher national certificate/diploma route and the remaining 500 would be educated in new courses "*directed to the development to the highest level of the teaching of the art of technology, based on sufficient scientific foundation. Such courses should have a status no way inferior to a university course, they should require equal ability in the student:* […]" They were to have "*freedom to plan their own syllabuses," (which the committee thought should be easily adapted to changing techniques), and "freedom* also to *award their own qualifications*." This should be done in "*a strictly limited number of technical colleges*." The new qualification which would be called "Diploma" would be guaranteed by a National Council that would oversee national standards. It is not part of the purpose of this paper to discuss the responses to the Committee's proposals (there were many) in the ten years that followed its publication but to come immediately to the actions taken in 1955 and in 1956.

In 1955 The Minister for Education announced that a National Council for Technological Awards (NCTA) that would make awards to successful students of technology from technical colleges and help those colleges develop, and maintain high standards of technological education. The Council was to be chaired By Lord Hives who was also chairman of Rolls Royce. The Council created the award of Diploma in Technology (dip.tech) to equate with that of a university degree. Entry to the new diplomas was the same as for universities with the exception that holders of 'good' national certificates were also eligible. The courses were to be full time or sandwich based which was intended to be the norm. Hot on the heel of this development in February 1956 a White Paper proposed the reorganization of the technical education sector [8]. A White Paper proposed a four tiered overlapping hierarchy of public sector colleges. At the apex would *Colleges of Advanced Technology* (CATs). They would offer a technological education comparable with that offered by universities but of a different type. *Regional Colleges of Technology* (of the order 30) which were intended to do advanced level work, although some lower level was likely to be retained. They were intended to respond to the particular technological requirements of their geographical region. *Area Colleges* (nearly 200) were intended primarily to undertake work up to the level of the Ordinary National Certificate some being allowed to do more advanced work. In the fourth category were *Local Technical Colleges and newer Colleges of Further Education* (of the order 300) that would concentrate on part-time study up to the ordinary national certificate. Both the CATs and the Regional Colleges could seek to have courses approved for the dip.tech. In the 1956 White Paper 8 colleges were listed as having CAT status. One, Brunel, was added to the list in 1962 (table 3).

The Diploma in Technology (dip. tech.) [1, 9]

Diplomas in Technology were awarded in engineering (dip.tech eng) and applied science subjects (dip.tech). The courses were sandwich based with students of two kinds. There were those supported by an employer (industry based), and those who had to find their industry

Table 3

Designation as CATs 1956	**Re-designation in 1966**
Birmingham College of Technology	Aston University
Bradford Technical College	Bradford University
Bristol College of Technology	Bath University
London Battersea polytechnic	University of Surrey
Chelsea Polytechnic	Merged with Kings College, London University
Northampton Polytechnic	City University, London
Loughborough College of Technology	Loughborough University of Technology+
Salford Royal technical College	Salford University.
Welsh College of Advanced Technology (Cardiff)	University (of Wales) College Cardiff

*Acton Technical College designated as Brunel CAT in 1962. Became Brunel University (London). + Subsequently Loughborough University.

places (college based). Industry based students had their fees paid by their employers and received a wage whereas college-based students had their fees paid by local education authorities and may or may not have received re-numeration from their employer during their industrial periods.

The most popular form of sandwich course was the 6 month x 6 month pattern over four years. Some began with the first period in industry others with it in college. They were nick-named "thin" sandwich courses. In contrast "thick" sandwich courses were of two varieties. The first began and ended with a year in industry with three normal academic years in between (1-3-1). University departments often participated in such arrangements. The other began with a year in industry which was followed by two years in college, then a year in industry completed by a year in college. An interesting variant was one year in industry followed by two six month periods in industry during a three year academic programme.

When the dip.tech courses began employers with training schemes of the kind described above had a considerable range of courses and institutions to choose from which to send their "apprentices." The addition of the dip.tech increased their choice. It was costly compared with the sponsorship of a student on a 1-3-1 course. The cost in 1961 of a 1-3-1student was £1400 ($3920) compared with £2000 ($5600) plus for a dip.tech student [9.p 163]. It is with the role of the electrical and electronic engineering industry in the promotion of the dip.tech that this paper is concerned.

Industrial support for the Diploma in Technology

From the foregoing it will be seen that the success of the dip.tech would be dependent on the support it received from industry irrespective of whether the students were industry or college based. The figures given above hide the fact that support for day release among industrial organizations was much less than universal. The firms with attractive student training schemes tended to be in the medium to large category. Bearing in mind that firms had a range of options open to them it is perhaps not surprising that relatively few organizations supported the dip.tech [9.p128]). When the diploma was ended in 1964, 456 organizations were supporting dip.tech training. The smaller firms that supported training seemed to have a high ratio of qualified staff. The nationalised industries, particularly electricity, gave considerable support to the scheme, and there was considerable support from large firms in the chemical industry. By the closure of the NCTA it had graduated 627 persons in applied science subjects of which 308 had read some form of applied or industrial chemistry and 297 applied physics, and 2250 in engineering subjects, of which 1682 were in electrical and mechanical engineering [9.p 139]. This suggested that the Diploma was beginning to meet the demand for an output of 500 graduates per annum (see above). First year enrolments even allowing for future wastage (drop-out) were keeping pace even though wastage had been high.

The successful launch of the Diploma depended in no small way on the electrical engineering industry. Of the first thousand diplomats over 30% were sponsored by firms in the electrical and electronic manufacturing industry, and as table 4 [9.p746] shows one firm alone, GEC, accounted for 20% of the output. Other firms in the industry contributed but with relatively small numbers compared with the big three (table 5 [9.p167]). Without the support of these three organizations dip.tech student numbers would not have risen at anything like the rate that actually occurred.

Notwithstanding, the support of the electrical industry, more generally it was found that employers looked on the dip. tech. to act as an incentive for the attraction of able students into industry. The willingness of employers to provide training places for both college and industry based students was a major factor contributing to the development of these courses [9.p 164] but some of them had concerns about the structure of *thin* sandwich courses and others about the curriculum direction they were taking. Among them were the electrical and electronic manufacturers.

Table 4

Contribution of the three largest electrical engineering firms to the growth of the dip.tech as a function of the total diplomate output up to April 1st 1962. (NCCA Records) {9. p 746)

Company	No of industry based students	Approx %.
G.E.C	204	20
English Electric	58	6
AEI	51	5
Total	**313**	**31**

Table 5

No of industry-based diplomates supported by individual firms based on data available in 1962. {9.p167)

Subject	**1 student**	**2-10 students**	**11-20 students**	**21-30 students**	**31-40 students**	**41-50 students**	**51+**
Mechanical	41	32	4				
Production	16	13					
Electrical	29	23	2	1	1		1
Applied Physics	12	15	1				
Electronics		2					
Chemical Engineering	6	4					
Metallurgy	9	7	1				
Applied Chemistry	10	17					
Aeronautical	1	3					
Applied Biology	2						
Inst and Control Engineering	3						
Civil Engineering		4					
Totals- firms	**129**	**120**	**8**	**1**	**1**		**1**

The Electrical and Electronic Manufacturers Joint Education Board (EEMJEB).

Given the large investment that these large firms had in training it is not surprising that they should come together in 1960 to create a Board that would represent them in the policy making world of education and training. In their 1961 annual report they criticised colleges running dip. tech. courses for not introducing *end-on* courses. "*The growth of sandwich courses in the past few years has produced certain problems in the training field. In most companies it has resulted in overloading of their training facilities for half the year and a relatively slack period for the rest of the year. The busy period also coincides with the university long vacation and makes it increasingly difficult for those companies who are engaged in running sandwich courses to take vacation students from the universities and colleges. One way of avoiding this overloading for the half year would be a far wider adoption of end-on sandwich courses, which would improve training facilities by increasing capacity and effectiveness. Each college would run two courses per annum, commencing in September and February, instead of one course beginning in October or September as at present. The Board felt that the position was so serious that representations should be made to the Ministry of Education without delay.*" [9. pp 515/17].

This they did, and the result was that a sub-committee of the National Advisory Council on Education for Industry and Commerce was established to investigate the problem. Its chairman was Sir Lionel Russell Chief Education Officer of Birmingham [10]. E. R. L Lewis who was Controller of Education of the English Electric Co. was invited to represent the Board on this sub-committee. The Board was also supported in its stance by the London and Home Counties Regional Advisory Council for Technological Education.

During 1960 representations to the Board of Governors of Birmingham CAT led to a college working party that included a representative of the General Electric Co (GEC) among its members, concluded that there was need for research on the issue. The Head of the Department of Industrial Administration Dr T. Lupton (later Director of the Manchester Business School) was asked to draft a proposal. He suggested a more general approach to the evaluation of sandwich courses that incorporated the end-on issue. He received an award from the Nuffield Foundation for his proposal thus causing a generalised study of the system.

Faculty were concerned that their duties would be doubled and that such programmes would be introduced without adequate resourcing. There was much opposition to them. Senior management in the Colleges thought that if they were introduced the number of students would be increased. The Birmingham initiated study found that this was unlikely to be the case. A few colleges initiated end-on programmes.

EEMJEB also complained about the syllabuses that were offered. "*In the early days when the proposals for the award of a Diploma in Technology were discussed the electrical and electronic engineering industry were under the impression that the courses leading to the award would be modelled more clearly on the needs of industry than on courses leading to a university degree. The new award for the Diploma in Technology (Eng) was therefore welcomed as being complementary to the university degree by meeting more fully the growing variety of needs both in the profession and industry. The industry is however disappointed at the general tendency for diploma in technology courses to follow the lines of conventional university courses rather than to strike out on the new and complementary lines that were envisaged to meet modern industrial requirements. These to include the need for technologists trained and qualified to undertake projects of conception, design, manufacture and operation that will be such as to put British industry in the lead and to build up trade against increasing technological and economic competition in all parts of the world. The Joint Board considers that the question of the nature of the diploma in technology courses in electrical and electronic engineering is of both importance to national prosperity and it is therefore advocating that steps should be taken to bring the courses progressively in line with modern trends of industrial needs.*" [8. pp 517/518].

Rather than being complementary to university degrees the diploma courses were aping them, a phenomenon known as "curriculum drift" wherein colleges offered similar programmes to institutions perceived to have higher status. This criticism of EEMJEB whether justifiable or not is supported by other evidence. First, the external examiners of the dip.tech who were often university professors were of the opinion that universities and the CATs were moving in the same direction. But they attributed considerable value to the industrial training [9. p 340]. They reported little difference between dip.tech examinations and those set in the universities. Second, both in terms of student expectations and work actually done as graduates the distinction made by the Percy Committee that universities should be the primary trainers of R & D personnel that dip.tech students expected to go into R & D or Management. Among the diplomates from whom data was obtained 38% were in research suggesting that their courses had not prevented them from getting a research post. As for their future careers the diplomats in this sample looked toward having increased responsibility for the work they did [9. p 444]. But, at that time industry indicated that the majority of their future graduate employees would enter management [8. p 438] which gives some significance to EEMJEB's comment.

One particular aspect of the career perceptions of students deserves particular comment. It relates to engineering design. The perceived failure of industry to produce good engineering designs led the government to establish a committee under the Chairmanship of G.B. R Feilden [11]. His committee reported in 1963 and among its recommendations was that candidates for Membership of the Institution of Mechanical Engineers should require experience of design. Further the Engineering Institutions Joint Council should consider a new category of membership to include technicians and draughtsmen. Support for the teaching of design was to come from a study of the attitudes to their education of mechanical engineers by Hutton and Gerstl presented to the Institution in 1964 [12]. Their ideal university course would include a 19% allowance for design engineering and speciality education. Remarkably in the English context 21% was to be available for general education. It was remarkably similar to the proposals put forward by the Grinter Committee to the American Society for Engineering Education [13] (table 6, [14]).

Table 6. Ideal University Courses of Study in Mechanical Engineering derived from Hutton and Gerstl's research [12] and the Grinter committee [13].

Topic	**% Total Time**		
	Hutton & Gerstl (UK)		**Grinter Committee (USA)**
English and Humanities	7		
Technical Report Writing	7	21	30
Foreign Languages	7		
(Liberal Studies in the US)			
Industrial Administration and Social Science		10	
Fundamental sciences; Maths, Physics, Chemistry		23	25
Basic Engineering Sciences eg Strength of materials		27	25
Design Engineering,	13	19	25
speciality engineering e.g instrument, textile	6		
Totals (%)		100	105*

- The mis-match is due to difficulties in making direct comparisons between the studies. For example Social Science could be classified a liberal study in the US

A major problem was that only rarely did universities show any interest in design. It was not a respectable subject, and in any case it was debatable as to whether it could be taught. This was not the case among those who undertook project work especially in dip.tech courses who believed that they helped students understand the design process. W. A. Pullman argued that because of the industrial experience obtained on sandwich courses students could undertake ambitious projects [15]. His paper is of added interest because it described project work at Rugby College of Technology, a college that was dependent for many of its students on Rugby's two major employers', Associated Electrical Industries and English Electric.

Perhaps the biggest problem is that the term "design" was used in a variety of ways by industry. For many the stereotype was of a designer draughtsman and as Monk showed engineers did not see time in the drawing office as contributing to their careers. Lord Hives said "*The usual university graduate does not take kindly to drawing office work*" but he went on to say "*Industry is largely responsible; there is not sufficient encouragement to create first-class designers*," [cited in 9] and he linked the problem to the value attached to applied science by society at large. In his definition, the designer is a member of the team of production engineers. He saw a unity of design, development and production that could not be shown in an organizational chart. G. S Bosworth in a striking paper on creativity in engineering in 1963 wrote that "*the increasing complexity and division of industry has now not only separated design from manufacture but has subdivided the design process itself into stages*"[16].

A Senior industrialist said that while Hutton and Gerstl's report was of interest "*it will bring us no nearer to solving our cardinal problem which is to establish the types of dip.tech syllabus which will best suit the holder of the dip.tech to do the things industry will require of him*." [9]

It was difficult to find very detailed comments. The complaint that dip.tech graduates would not be able to "*undertake projects of conception, design, manufacture and operation"* leads to the question why were they not put on such projects during the industrial period, and what was wrong with the substantial projects that students undertook in college in their final year? No detailed investigation of curricular was undertaken neither was there any formal investigation in to what students learnt in the extensive projects they did from this perspective.

One survey of members of the Association of British Chemical Manufacturers reported half of them as saying that the quality of chemical engineers was not very satisfactory because they were not able to write reports, lacked cost consciousness, and did not fit harmoniously into the working environment. This was typical of comments to be made about university education in later years (see below) [9].

Many questions arise, among them is one that does not seem to have been investigated, that is: why were these industrialists not able to influence the college advisory boards or boards of governors on which they sat? Why were not the colleges organized such that industrialists might have more direct influence on their work? Part of the problem was that there was a tradition that the work of the colleges should be left to the colleges and the work of industry to industry. Another component would be the fear of academic staff that what industry wanted was training. A contributory factor was that there was not a common technical vocabulary available to them for discussion of curriculum issues. For example, at that time Tyler's principles of curriculum had not become part of educational thinking in the UK. The "Bloom Taxonomy" was unknown in the UK [17]. Moreover, there was no forum for the discussion of the higher education curriculum *per se*.

But taking all the evidence together there was little to suggest that overall industry was generally dissatisfied with dip.tech syllabuses. Nevertheless there was a response from government to the criticism of EEMJEB. Yet another committee, chaired this time by G.S. Bosworth.

In the meantime the Robbins Committee on the future of Higher Education had published its report in 1963 [18]. It accepted the view that the appropriate courses offered by the Colleges of

Advanced Technology were of degree level standing. Therefore, they should be given university status. So between 1964 and 1966 they were busy preparing for independence and university status and the Bosworth Committee had to take this into account. The debate then began to move away from sandwich courses and the training of different kinds of engineer but rather to the training of product technologists.

A report on the education and training requirements for the electrical and mechanical manufacturing industry (The Bosworth report) [19].

G. S. Bosworth was Director of Personnel and Training of the English Electric Group. Educated as an engineer he was a member of the establishment. He had served on the Crowther Committee that had evaluated the education of the 15 to 18 age group [20]. In 1963 he had published the significant critique of engineering education referred to above.

The solution to the training of product technologists was not regarded as a matter of curriculum orientation or syllabus content by the committee for "*the emphasis given to the principles of engineering science is, in our view, correct since it is on these foundations that technological advance is based*." The committee proposed a "matching section" within an industrial context as a means of induction to manufacturing. Their thesis adopted the view that a person should be developed in parts. The theoretical part first, the practical second. It assumed that basic education did not over-orient the student to the analytical approach and thus to an interest in research. It further assumed that basic education had little effect on overall motivation and that students entering courses for an industrial career would remain motivated to this end. There was also the assumption that teaching methods could not be changed to help develop the attitudes of mind required of the young engineer in industry. These assumptions are highly questionable and there was some criticism of them at the time. Although they led to suggestions for the development of post-graduate training the committee recognized that some of their recommendations were relevant to undergraduate education and training. "*The view was strongly presented by young graduates particularly, that several of the elements of training we proposed could with advantage replace less relevant material in the undergraduate courses. Manufacturing engineering was instanced, and we believe there should be further enquiry into the means of providing an element of practical content with manufacturing engineering in or before the full time degree course*." [19] Several writers suggested that training of the kind described should be included at the beginning of a university course or in a first year in industry (1-3-1 type) and that much of what was suggested for matching could, with profit, be included within the undergraduate course. These writers argued, that contrary to the committees assumptions that teaching methods and examining techniques were fundamental factors contributing to the qualities required of engineers in industry. They argued for research into the curriculum [9. pp 489 – 491].

Postscript

A corollary of the Colleges of Advanced Technology being raised to the status of technological universities was that the NCTA had to all intent and purpose lost its rationale although there were a number of dip.tech courses in the Regional Colleges. However the Robbins Committee recommended an expansion of higher education generally. It believed that some of the regional colleges merited the status of universities. Students in the public sector should be able to take a wide range of degrees. Accordingly it proposed that a Council for National Academic Awards (CNAA) replace the NCTA with power to cover other areas outside of science and technology. The government approved this recommendation and the Council was established in 1964 with the officials of the NCTA as its servants. It was to award degrees not diplomas [6].

In 1966 a White paper proposed the establishment of high level teaching institutions but with some research with an orientation towards the needs of industry [21]. Their teaching staff should be encouraged to do research. They were to be called “Polytechnics.” Many of the regional colleges were so designated in 1968. Where appropriate mergers took place between the regional college and other institutions such as colleges of art and commerce, and teacher training. They were part of the development of full-time higher education in the UK.

At first the CNAA more or less required that engineering courses should be sandwich structured but by 1970 R.C. Winton, an industrialist who for many years was secretary of the UK chapter of the IEEE reported that “*there was a heavy swing away from the sandwich course to the full time course.”*[22]. In a way that was not surprising because there had been enormous changes in the electrical and electronic manufacturing industry. The big three companies that had been the spearhead for the dip.tech were taken over. The General Electric Co which had merged with SOBELL and Sir Michael Sobell’s son in law Arnold (later Lord) Weinstock became Chairman of GEC. He set about making it a much more efficient organization. Such was his success that in 1967 he acquired Associated Electrical Industries that included the Metropolitan Vickers, British Thompson Houston and Siemens. A year later he acquired the English Electric Company which brought with it the prize of the Marconi Wireless Telegraph Co. This huge organization was the subject of economies of scale and many very able people found themselves redundant. For example, the Siemens works at Woolwich that had in 1874 developed the “C. S. Faraday” the first custom built underwater cable laying ship was closed.

The findings of the Association of British Chemical Manufacturers that graduates were not able to write reports, lacked cost consciousness and did not fit harmoniously into the working environment continued to be made by industrialists. But the complaint was generalized to include all graduates both from the humanities and the sciences. The criticisms were more about the affective domain than the cognitive and they were certainly not about content. These skill areas came to be known as personal transferable skills. In 1989 the Government through the Department of Employment rather than the Department of Education offered universities who were willing to develop personal transferable skills across the university £1,000,000 to be spread over five years to achieve that goal. The project was known as the Enterprise in Higher Education Initiative [23]. The curriculum continues to be the subject of debate.

Comment

The attempt to develop an alternative and different curriculum for engineers wishing to go into industry never had a chance. To equate a diploma with a degree was, in the culture that is England and Wales, to create a lower status animal. It came at a time when an increasing number of students with a good secondary education were seeking admission to university. In these circumstances it was not surprising to find a "curriculum drift" in which technical college curricular began to mirror university curricular.

Undoubtedly the early and rapid success of the dip.tech was due to the large electrical and electronic engineering companies. Had twelve years elapsed and the diploma been established then these companies would not have been able to give it the support they did. If there is a lesson in this history it is that then as now industry is subject to change, some of it rapid and momentous in so far as employment is concerned. What is required is a workforce that is adaptable and flexible and able to change specialisms and jobs as they become redundant. This suggests that new approaches to the curriculum continue to be required.

Toward the end of the period under consideration (1966) a group of academics and industrialists gave thought to just such a curriculum at request of the Vice-Chancellor of the University of Lancaster, Charles (later Sir) Carter who had an interest in engineering. His father, a Fellow of the Royal Society had been Director of Research at the British Thomson Houston Company in Rugby and his brother was Professor of Electrical Engineering at Leeds University. After the university had been founded in 1964 he introduced early on a Department of Systems Engineering to complement a Department of Operational Research. But unusually he made known his interest in developing a department of engineering and invited anyone with ideas to communicate with him. He encouraged this group of academics and industrialists to advise him and they prepared what the journal "*Engineering*" called a "voluminous report" on the education of professional mechanical engineers for design and manufacture. This title is somewhat misleading because the model worked from a broad base toward a specialism. That specialism could equally have been electrical engineering. Carter believed that a new approach was needed and this was reinforced by meeting that he had with Sir Willis (later Lord) Jackson F.R.S. who told him that the University Grants Committee (UGC) was unlikely to sanction a request for three traditional departments (ie civil, electrical and mechanical). Sir Willis had been Director of Research at Metropolitan Vickers and was now Professor of Electrical Engineering at Imperial College. He advised both the UGC and the Manpower Committee so his comments were rather important. The group produced a curriculum [23] that was by any measure radical and Carter drafted a proposal that made use of many of its ideas. It failed to get past Senate so he produced a somewhat watered down version that did get past Senate and a Department of Engineering was approved. The design of the second year was radical but remains of interest.

The model was based on the sandwich principle. A carefully designed first year in industry was to begin the courses. The second year (or first academic year) did not follow the normal pattern. The aims of this session were cited as "*To make an alternative approach to the teaching of engineering science called "engineering analysis". To reinforce the experience of the first year.*

This is achieved partly in "engineering analysis", and partly in "engineering synthesis" […] which is an attempt to introduce the students to all aspects of design, e.g, the customer, quality control, working in teams, ethics etc." [24. p 102]. The intention was that this should be achieved by an extensive project accompanied by a lecture programme that while having some independent progression, was allied to the project and its progress. Social science aspects were intended to be integral to this course. Finally there would be an extension of mathematics as a tool for solving problems.

It is however, the idea of engineering analysis that is of interest here. It originated with Bosworth and a colleague of his B. T. Turner. The group, in effect challenged the Bosworth Committee's thinking in that it wanted to "*develop an attitude of mind toward scientific problem solving in the industrial environment*". In the model which has been briefly described and illustrated at the 2010 ASEE conference the "*activities of engineering are related to the sources of engineering when, for this purpose, engineering , is defined as the practice of the art and science of making things. (Thus an object is created from sources in people, who use energy, forces, materials, space and themselves for its invention, and who in doing so ask a number of questions about its activity and the activities of the sources, location and acquisition etc. The teaching begins in the concrete and moves to the abstract, from the known and tangible to the unknown and intangible*."[24. p 103]

The authors believed that the total engineering need had to be considered and they considered that this would be achieved through "*the subject of design via the known and familiar, motivation becomes high and interest is at once around*." [..]. Later they argued that the "*student is concerned with the theory of the design procedure, and thus the methodology of manufacture. The student is shown how to look at the system (a) so as to formulate the problem, and (b) to obtain optimised general solution. In considering the system, he breaks it up it into sub-systems and components; he comprehends how sub-systems can be standardised, and learns how to use them as building blocks, since new design is often modification of an old one*." […].[24.p103] The authors intended that a problem solving approach would be used that was based a carefully chosen set of exercises (mini-projects). Today we could call it problem-based. They also insisted in the jargon of today that the programme was an integrated study and not an interdisciplinary study. They concluded that "*the overall aim is to develop a philosophy of engineering"* […].They thought that part of induction course to the scheme should be devoted to the philosophy of engineering [24.p105] This brings us to the present for during the last five years there have been a succession of conferences and papers in search of a philosophy of engineering and engineering education. The study would still seem to be relevant to, for example, Rosalind Williams thesis that engineering has lost its identity because it has become too specialized [25]. In this model the intention was bring in the traditional engineering specialities in the third year after a general study of what engineering was all about. If it is accepted that all engineering is about the attainment of a product whether soft or hard, then that is the source of an engineer's identity and not the specialism. For Bosworth it was about product technology and that covers a multitude of specialisms.

Notes and references.

Sources. The principal source of data for the introduction is Payne [1]. Payne's study was undertaken at the request of the US President's Committee on Scientists and Engineers that served between 1956 and 1958 under the aegis of the National Science Foundation. It contains a wealth of published and unpublished policy information. Included is a substantial bibliography that incorporates an annotated list of legislation and official reports. In 1971 this was updated in substantial bibliography and commentary by Heywood [2]. A useful back up study will be found in Cotgrove [3]. A specific case study of staff and student attitudes in a College of Advanced Technology will be found in Jahoda [4]. For the period up to 1955 see Venables [5]. For additional information on the NCTA and the CNAA in particular see Silver [6]. The sections on the dip.tech, industrial support for the diploma, and EEMJEB are based on previously unpublished data in [9].

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[23] See ref 17 chapter 2 for a discussion of the Enterprise in Higher Education Initiative.

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[25] Heywood, J (2010) "Brief Encounter". A reflection on Williams proposal for the engineering curriculum. Paper 1296. *Proceedings Annual Conference of the American Society for Engineering Education*. The paper includes an illustration from the matrix but it is not discussed with the present point in mind.