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Culture and the development of a unique sub-system for the education for engineers in the UK: A historical study. Part 2. Its accidental evaluation.

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Culture and the development of a unique sub-system for the education for engineers in the UK: A historical study. Part 2. An informal evaluation.

Abstract

This evidence based study follows from a previous paper which described the origins of a unique sub-system of higher technological education that was fortuitously established by the British government in England and Wales in 1955, and lasted for a decade. Although no official evaluation was ever undertaken of the colleges that formed that sub-system, a number of investigations into different aspects of the diploma programme that was the core of the system were completed. The specifications of one of these studies accidentally required a study of the system, or at the very least "pictures" of the functioning of different components of the system. Unfortunately the study of the system as a "whole" was never published.

However, inspection of the other investigations suggests that taken together their parameters would provide an informal evaluation of this sub-system. The intention of this discussion is to undertake such an evaluation. But no attempt is made to incorporate into the discussion the results of work undertaken by other authorities that was tangential to or in any other way related to the development and demise of the sub-system.

The system and its development described in the previous paper demonstrated the importance of understanding the culture in which educational decisions are made, for those decisions are a reflection of the society in which they are made. Opportunities taken, and opportunities lost are a function of those mores; for some a decision will be an opportunity to be taken, and for others it will be an opportunity lost.

This study confirms the importance of "culture" in educational decision making, be it in terms of career choice, institutional status, or curriculum and teaching.

Following a brief introduction, essentially a short precis of paper 1, answers to fourteen questions derived from the philosophy of the Percy Report, and other elements of its discussion are given in the light of the findings of the investigations undertaken.

Taken together these papers raise questions about the scope of engineering education research. Most of the participants in the investigations reported here were working in social science departments; several in pursuit of higher degrees. Given that the Percy and other official committees used the term technology (ist) to describe engineers, and given that the public may think in this way if they are not thinking about IT and smart phones, might not a better expression of the area be engineering and technology education research?

A list of abbreviations together with a time line is given at the beginning of paper 1.

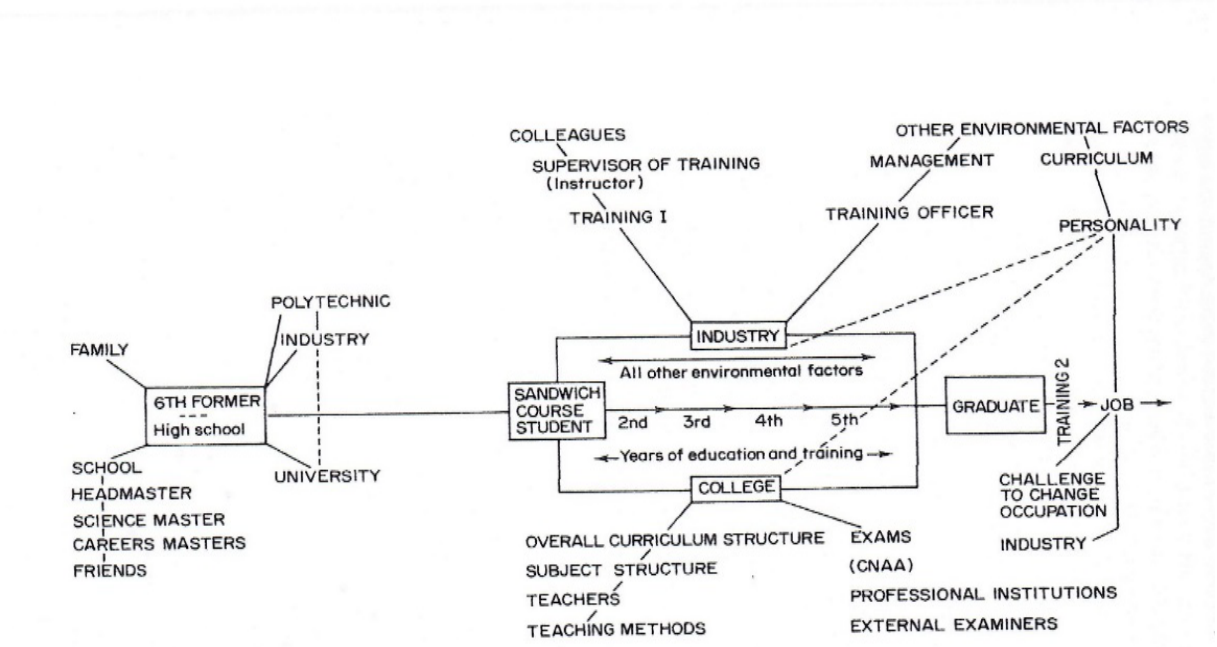
Introduction

A previous paper (part 1) derived from work in progress on the history of engineering and technological education described how from a systems perspective the UK Government implemented the proposals of the Percy Committee on Higher Technological Education a decade after they had been made. Fortuitously, at least from a research perspective, a relatively open sub-system for the education of engineers and technologists for industry, the

focus being on engineering, was established. Such persons rather than pursuing a career in R and D would seek employment as engineer managers in the areas of design, manufacture, operations and sales. Such engineers were believed to be in short supply. Senior administrators would be drawn from this group as well as from R and D personnel that had been trained by the universities. “There is a strong feeling in industry that in planning professional courses generally more attention should be paid to developing not only technical knowledge and skill , but also a liberal outlook on life, some appreciation of the organisation of industry, and an interest in administrative problems” (para 11).

It was argued that the technical college sector was particularly suited for this type of work, since it embraced the art of technology with the science, and training with academic study. Therefore, the sandwich course principle should be adopted, thereby allowing for an increase in academic study time particularly in the maths and sciences, and the planned integration of academic study and industrial practice. In this way Britain’s pre-eminence in manufacturing would be maintained.

In 1955, the government established a National Council for Academic Awards (NCTA) for the purpose of accrediting a degree equivalent diploma (dip.tech) during a four year period arranged on the sandwich (cooperative) principle. It would be subject to external examination in the same way as a university degree. The dip.tech would be available to colleges in the technical education sector with experience of functioning at this level. For this purpose, ten of these institutions were raised to the status of College of Advanced Technology (CAT). These colleges formed a distinct but overlapping sub-system complicated by the fact that other suitable technical colleges and polytechnics could also offer dip.tech programmes. A model of the sub-system from the perspective of a student moving through it from entrance to graduation is shown in exhibit 1.



A descriptive model of a subsystem of higher education which shows the forces acting on a sandwich (co-operative) course student in a College of Advanced Technology or polytechnic in Britain. (See Chapter 2 for a discussion of this figure.) (From Heywood, J. (1974c). *New Patterns of Courses and New Degree Courses*, Strasbourg: Council of Europe)

Diploma programmes were initiated in 1955/56, but by 1961 the electrical engineering industry had become dissatisfied with the sandwich structure of many of them because they did not allow firms to keep training places open all the year round. Also, some of their members believed that their needs would not be met without radical changes to the curriculum. At the same time over the period of the existence of the sub-system (1955 – 1964/5) there was a move away from industry-based students to college-based students.

In this same period the National Foundation for Educational Research obtained details of well over a hundred research projects that had either just been completed, or were in progress, or just beginning in 1964 related to technical and technological education. All of the CATs, except the one that did not offer dip.tech programmes, had persons investigating aspects of the dip.tech. By 1965 three books had been published on those aspects Altogether the important dimensions of the sub-system were investigated. It is these investigations, and these investigations alone that are the focus of this paper, the purpose of which is to examine the extent which the Percy Committee's philosophy set down in *Higher Technological Education* (HMSO 1945) was achieved. These investigations are no 2 to no 22 in the list of references, and referred to by the investigator's name in the text.

The discussion is presented in the form of a series of questions and answers that reflect the author's interpretation of what the research had to say, and are derived from a more substantial history of engineering education in the UK that is in completion. A tabulation of the questions, summary responses and related publications, is given in exhibit 2. The questions relate to whether or not the policies envisaged by the Percy Committee were achieved, but not to the educational experience that the students had had which was considered by the two major inquiries of Jahoda [2] and Marris [3].The surveys into the mathematical requirements for electrical engineers [16], and metallurgists [17] initiated in two of the CATs were also not relevant to the question set.

In sum, the Percy Committee's proposal that the diploma should be equivalent to a degree was accepted. (Qu 1). Was it perceived to have lower status as some members of the Committee thought would happen? (Qu 2). Did the compulsory requirement for liberal studies improve the image of the diploma programmes and the CATs? (Qu 3 which is considered together with Qu 2). Were the industrial studies suggested by the committee incorporated in the diploma courses? (Qu's 4, and 5). What impact did they have on course design and did they trouble students (Qu 6). The Committee hoped the Ordinary National Certificate could be developed so that it would be recognised by the universities. Did the ONC students perform as well as the 'A' level entrants to the diploma? (Qu's 7 and 8). The Committee thought that the diploma course should focus on the production of engineer managers (design, manufacture, operation and sales), but not on researchers. Did the courses achieve this goal, and was industry happy with the resultant distribution? (Qu 9 and 10a). Did the industrial training produce the different kind of technologist that some industrialists wanted? (Qu 11)

Given the dissatisfaction of some industrialists with the structure of sandwich courses, and given the belief of the Percy Committee that industry was short of qualified technologists was there any evidence that changing the structure of some courses would have increased the number of students on courses? (Qu's 12 and 13 treated together). The Percy Committee

believed that the period of works practice should be as carefully planned as academic study. Was this goal achieved as measured by the experiences of students? (Qu 10a).

What was the government's response to the development? (Qu 14).

Question	Summary response	Associated Publication
1. Was the dip.tech equivalent to a university degree?	No evidence to say it was not	8
2. Were those members of the Percy Committee who argued that the use of the term diploma would cause the qualification to be seen as low status, correct?	Yes	4
3. Did the fact that the diploma courses required compulsory programmes of liberal studies impact on their image positively?	No	4, 19
4. Did the Percy Committee have anything to say about studies other than engineering?	Yes, about subjects related to industrial administration.	19, 20
5. Were such studies covered in liberal studies programmes?	Yes, in many programmes	20
6. Were students satisfied with the liberal studies they received?	Most were but there were suggestions for change.	19, 20, 21
7. Were the Colleges justified in accepting students with alternative qualifications to 'A' levels?	Yes	11, 12, 13, 14
8. Were withdrawing college-based students treated differently to industry-based students by industry?	Yes	15 also reviewed in 8, 23
9. Did the products of the dip.tech pursue employment in industry in R & D?	Yes	5, 8, 18
10. (a) Was industry happy with this situation? (b) Was the students' experience of industrial training satisfactory/unsatisfactory.	The major supplier of places was not but the others mostly were Mostly satisfactory	8 2, 3, 9, 10, 22
11. Was there any evidence that industrial training produced different types of technologist to those produced by traditional three year course other than that to be expected?	No	2, 3, 8
12. Was there any evidence to indicate that one structure of course (full-time – thick sandwich, thin sandwich) was better than another?	No. Each had advantages and disadvantages	2, 3, 8, 9, 10, 18, 22
13. Was the presumed shortage of qualified scientists and technologists sufficient to justify the colleges being required to run end-on sandwich courses?	No	7, 8
14. Did government policy influence the academic direction which these courses (and colleges) took?	Yes	8

Exhibit 2. Summary of questions posed by the Percy Committee's Report that may act as indicators of the success or otherwise of dip.tech courses and the Colleges of Advanced Technology related to investigations emanating from the colleges in which information is directly or indirectly related to the question posed.

Commentary

Qu.1. Was the dip.tech equivalent to a university degree?

While this is the most important question, it is very difficult answer since there were no comparative psychometric studies, or comparisons of answers to examination questions set made by independent investigators. However, the system believed that this was the case, and the external examiners did not dissent. The British system relied on external examiners to judge that candidate's marks are fairly awarded, and are comparable with the marks awarded for similar work in other colleges and universities of which they are supposed to have cognisance. At the time it was assumed that this system was reliable, and valid. Seventy of the external examiners were university professors, including a number of Fellows of the Royal Society.

Heywood wrote to each examiner for their views, and interviewed a few [8]. The best that could be said of the information acquired, was that there was no reason to suppose that the standards of the dip.tech differed to those of the technological degrees awarded by the universities. One Fellow of the Royal Society and senior policy maker told the investigator, that, since the teachers had been brought up within the university system, it was no surprise that they should imitate it.

Questions 2 and 3 are considered together.

Qu 2. Were those members of the Percy Committee who argued that the use of the term diploma would cause the qualification to be seen as low status, correct?

Qu 3. Did the fact that the diploma courses required compulsory programmes of liberal studies impact on their image positively?

'Yes', to question 2 and 'No' to question 3. Heywood, Pollitt and Mash asked head teachers, science teachers and careers teachers and some sixth formers about their opinions of the CATs [4].

The teachers gave the impression that the CATs were second class institutions, yet in respect of the subjects taught, 55% believed that the CATs were better than or as good as the universities. A question on the relative 'goodness' of these institutions found that about a third of the respondents thought the CATs were not as good as the universities. However, matters changed when questions were asked about liberal education, because in this respect, very few teachers thought that the CATs were as good as the universities, and this, in spite of the substantial programmes of compulsory liberal education offered by the CATs, which many teachers thought were not necessary. 40% or so of the respondents associated liberal education with the ability of students to mix with others from a wide range of faculties.

If that was the case the CATs came off poorly when rated against universities. For example, Marris found that over a third of the Northampton CAT students never took part in college activities which was three times as many as the students in universities never participating in such activities [3]. Jahoda found that 20% of the students at Brunel did not participate in student activities and that "there is a decided trend among the experienced engineers not to get involved in organising activities" [2].

Davies who critiqued Heywood, Pollitt and Mash's report [4] also showed that teacher understandings of liberal education were confused and weak [19].

At the same time it was by no means clear that school teachers had much influence on their students' choice of the higher education route to be followed.

Sixth formers in these schools it seems, did not regard the CATs other than some form of technical college with its image of "earning while- learning". It was difficult to escape the view that many sixth formers associated the CATs with the technical college system and the colleges were, therefore, second class citizens.

Notwithstanding these images, the dip. tech and the CATs provided an alternative higher education route for students of science and technology at a time when the demand for higher education, preferably at University, was increasing. Although they had had no experience of university some diplomates would have liked to have gone to university, and a number of those with 'A' level qualifications had applied to go to university. But, Jahoda pointed out that failure to go to university might have been due personal financial circumstances, and not qualifications [2]. Image was important factor in determining the pathway that students took.

Qu 4. Did the Percy Committee have anything to say about studies other than engineering?

Yes, but they were not about liberal education. They appeared in the concluding recommendations (para 72). The committee considered that ignorance of the "main findings" of such subjects as scientific management, industrial psychology, costing systems and methods of wage payment in "the academic courses of technicians" (this would seem to embrace technologists) would be "a severe hindrance to them in later life". Lack of such study "is a real handicap to me who would otherwise be highly qualified for administrative work".

Qu 5. Were such studies covered in liberal studies programmes?

Aspects of these studies were available in some liberal studies programmes. Among the diplomates interviewed Heward, Mash and Heywood were those who considered that any liberal study should have relevance to their intended occupation [5]. They valued subjects like economics, human relations, and industrial administration. Andrews and Mares called these "tool/ fringe" in contrast to "cultural" subjects. They had drawn on 250 students from thirty-four colleges including CATs, and eighty firms, and found, that 50% of the students who claimed to have benefited from liberal studies, three quarters had preferred tool/fringe subjects and only 5% "cultural" subjects. Overall 39% of the students, and the same proportion of their technical instructors, favoured programmes that were focused on tool/fringe subjects, whereas the heads of liberal studies departments favoured a curriculum with both types of subject on offer, but with a bias in favour of the cultural.

Given the popularity of tool/fringe studies it is surprising that Davies study of the vocational preferences of dip.tech students found that only 27% of the engineers and 11% of the applied scientists said their aim was to become a manager [19]. Whether they thought management was part of what an engineer does is not clear because Davies separated management and teaching out as a specific career options.

Andrews and Mares also interviewed industrialists, and those who commented, took a utilitarian view of what should be studied [20]. Their results led them to suggest that the syllabus (content) should fall into four main divisions –language and communications, technical studies, social studies and optional (e.g in the humanities and creative arts). There was, as Davies showed, an extensive debate about what should constitute the cultural component, and he listed the content of very many syllabuses in this area [19].

Jahoda's study raised the question of the meaning of tool/fringe which in her study went beyond those listed by the Percy Committee. She was interested to establish if the Brunel CAT students wanted to augment their general studies programme [2] which focused on the three areas of English, Fundamentals of Science and Social studies. She and her associates found that engineers were more satisfied than scientists in that 88% of them, as compared with 57% of the scientists, made no suggestions for change. However, 23% of the scientists as compared with 6% of the engineers, wanted less general studies. By far the most popular field was the Fundamentals of Science – a tool/fringe subject. Unusually she had a large number of applied scientists in her cohort.

This argument about what the additional subjects should be has continued to the present day, particularly as it relates to instruction in the so-called 'soft-skills' required by industry. They are resented by many academic engineers and students on the grounds that they overload courses.

Qu 6. Were students satisfied with the liberal studies they received?

There was plenty of evidence then, as there is now, that students of technological studies have more formal contact time in lectures and laboratories than students following other disciplines. It might have been expected, therefore, that the addition of subjects distant from the main disciplines would have led to an unfavourable reaction to their inclusion. However, investigations of liberal study programmes by Peers and Madgwick, and Andrews and Mares did not find much opposition to such compulsory study [20]. Peers and Madgwick found that about 13% of their sample of students were hostile to such programmes [21]. While not recording hostility, Andrews and Mares reported that 24% of their sample of students said that they had obtained no benefit from them [20].

Davies pointed out that most of the respondents in these particular studies were from technical colleges; only 29% had attended CATs [19]. But, analysis of the diplomates views in the Birmingham study suggested that no more than 10% of the total responses could be considered as rejecting the idea of liberal studies. There were, however, those who felt the pursuit of liberal studies, by which they meant "high culture" (music, art etc), was a private matter: others thought they should not be formal, after all "*a university offers a liberal education in an informal manner*".

Taken together these investigations did not suggest that there was any substantial feeling that, to quote Davies "*time for liberal studies is begrudged*". That said, these investigations, and especially the extensive written responses in the Birmingham investigation, revealed a great many reasons for satisfaction and dissatisfaction with liberal studies. But, Peers and Madgwick found that the pressure of the academic period of study was too much to sustain these interests [21]. However, in the Birmingham study no more than 11% of the diplomates made comments directly related to the overloading of the curriculum.

In one way and another, the picture presented by the diplomates and students was of a new dimension added to their knowledge and perception of themselves, even though for some, the most remembered effects were enjoyment and relaxation from the rigours of the major study. The benefits were many and various, for the sake of becoming a more balanced human being. These findings have to be set against the fact that much confusion about the aims of liberal education was found among both teachers and students.

Qu 7. Were the Colleges justified in accepting students with alternative qualifications to 'A' levels?

Yes. Most of the students with alternative qualifications possessed Ordinary National Certificates. While initial adjustments had to be made for the different approaches to the curriculum and teaching that they had given, the Colleges believed that they performed as well as those with 'A' level. Hilary Dickenson showed that at Birmingham CAT they had performed better than those with two 'A' levels or other technical qualifications [11]. At Salford CAT, Walmsley and Chisholm found that up to 1962 in mechanical engineering, the ONC group had obtained a proportionately substantially higher number of first class honours and upper second class honours diplomas than the GCE group [12].

They came to a similar conclusion to that of G. N. Patchett who was Head of Electrical Engineering at Bradford CAT who had written, *"An examination of the students results in detail shows that there is no particular category of students which could have been refused entry to the course without sacrificing a substantial number of students who actually achieved a good performance on the course…"* [13].

Haslam and Hawkins at Woolwich Polytechnic, a non- CAT offering both dip.tech and degree programmes, found like Patchett, that success or failure in individual subjects in electrical engineering in first year gave little indication of ultimate success and failure on a course [14]. But, they also found that there was a good relation between the final result and the aggregate marks of the terminal (yearly) exam result.

They found that many students failed because they did not grasp the implications of the material being presented to them. They concluded that the term 'failure' should not be used for those who had repeated a year for "*if a student who gains a dip.tech., in five years is not considered a 'failure', the failure rate can then be reduced in a more constructive manner*". It was evident that this department accepted high failure rates for the sake of a broad entry.

But, as they pointed out, if entry qualifications were left wide a higher failure rate was to be expected, and when they were, wastage rates were high particularly in the first two years.

Davies as part of his psychometric study of students and their attitudes to liberal education at the Welsh CAT, found that there was no difference in intelligence between ONC and 'A' level candidates, but among the various technologies it was found that engineers were higher in intelligence (again in both verbal and non-verbal forms) than applied scientists. However when compared with university students, while their non-verbal intelligence was on a par with university students, there verbal intelligence was more like that to be found in a typical training college.

In sum many persons who would not, at that time, otherwise have received a university education were undoubtedly successful on these courses. By accepting students with National

Certificates, the colleges offering the dip,tech had access to a group of students whose performance compared favourably with that of students with 'A' level certificates.

Qu 8. Were withdrawing college-based students treated differently to industry-based students by industry?

Often. Given that industry supported many industry-based students through their courses the attitude of industrialists to failure was of some importance. Christine Heward (née Woods) who investigated withdrawals from Birmingham CAT, found that firms differentiated between the support they gave to industry-based students of engineering and students in other subjects [15]. Firms would support a student transferring to an engineering National Certificate because students possessing them were regarded as professionals by both firms and the professional institutions. This was not always true of National Certificates in the applied sciences. She wrote that "*less than a quarter of the respondents* (who withdrew from college) *left industry. Those who did leave industry were predominantly college based and/or applied scientists*". But, "*the applied scientists who had remained in industry had neither as many qualifications nor such good jobs or salaries as the engineers".* Of much more significance was her finding that firms rarely regarded withdrawal from college as evidence of failure. Heward wrote, "*They (the firm) re-define the employee's role and reallocate the student to another position in the social structure. Instead of being bereft of a frame of action the student, who is also an employee, has this second institution, his firm. The majority of firms presented alternative courses of action which the student accepted except in the few cases of those who left industry altogether. It seems that in most cases of withdrawal involving industry based students the initiative is taken by the firm in initiating subsequent action. This gives the industry based student a high level of security which is occasionally envied by less fortunate college based students*" [15 and 8].

Most of the engineering students were able to pursue courses for the higher national certificate and were successful in this respect. Unfortunately the number of industry-based students had already begun to decline, and dip.tech programmes were depending more and more for their survival on college-based students.

But, three years after Heward's rather optimistic study of withdrawal in 1963 [15], David Lee and Irene Hordley found in a comparative study of students at a CAT and a Technical College that the situation was changing [23]. They expressed concern at the increasing stratification of courses and wrote. They concluded that *"the situation is arising where the 'salvage' function of technical education will be inoperative*" .At that time the economic theory of human capital began to take hold in higher education.

Qu 9. Did the products of the dip.tech pursue employment in industry in R & D?

If the aims expressed in the Percy Report are taken as the criteria of success, then it would be expected that students would want to go into manufacturing and production rather than research and development. Universities would provide the personnel for research. In this respect the Diploma in Technology evidently failed.

Between 35 and 45% of students in five colleges offering the dip.tech were intent on a career in research and development, and that thirty eight percent of a sample of diplomates were actually employed as such. Of 76 diplomates interviewed, 7 were doing post-graduate work in universities. Data supplied by Matthews from Loughborough College of Advanced

Technology, showed that of a 10% sample of its students, the number wanting to go into research and design was 44%; management 24%: production, 25%, and technical sales 7% [p 438, [18 &personal communication]. The Percy Committee did, however, expect some diplomates to go into management.

Qu 10. (a) Was industry happy with this situation?

Qu 10. (b) Was the students' experience of training satisfactory/unsatisfactory?

(a) Given that they employed diplomates in R & D those firms that employed them must have been satisfied with the dip.tech programmes of their experience. But, there was an industrial group that thought the programmes were not meeting their needs, moreover it, the electrical engineering industry was by far the largest supporter of dip.tech programmes. It had supported approximately 30% of the first 1000 diplomates. The industry had two complaints. The first was that most courses were not structured on the end-on principle. They wanted a system in which training places were occupied throughout the year. They would, with the colleges, take two entries per year. There was much opposition to this from academics in colleges since the colleges would be open throughout the year. Nevertheless, several departments offered end-course. The Birmingham project was established to examine the viability of these courses primarily from the perspective of learning, and the supply of students and industrial places. A comparative study of two structures offered by the Department of Metallurgy at Battersea CAT was undertaken by Hornsby-Smith [10].

The second objection put forward by G. S. Bosworth was that the curriculum was oriented toward the needs of academia and not industry. It did not, therefore, produce a different kind of technologist [24]. The opportunity to take up his ideas was not taken up. An official committee that he chaired came to the conclusion that universities would not change at the undergraduate level and that the best way forward was by tailor-made post-graduate courses.

In terms of this particular inquiry it meant that if different kinds of technologist were being produced it would be due to the compulsory liberal studies, or the integrated industrial training, or both. But as Lawrence Davies pointed out liberal studies were about better educating the individual [19]. Differences, if there were to be any, depended on industrial training.

(b) The Percy Committee recommended that the period of works practice "should be as carefully planned as academic study and the whole should be planned by co-operation between the educational institution and the industry concerned".

In the decade that followed the Percy report the concept of integration was introduced, and much debated. The NCTA said "that training should illustrate the application in practice of the scientific principles which the student has been taught in college".

Jahoda one of those who had evaluated the student experience of industrial training found that "when students were aware of the connection between college and the industrial period, the chances of of a good experience are higher, if a bad experience much lower, than where such awareness is absent" [2].

More generally, it seemed that most schemes of training (irrespective of subject) could be divided into two parts, basic and secondary studies It was not then understood that sequence of instruction and training could be related to cognitive and personal development in a

sandwich course. A review of the research by the author concluded that the number of students having a bad experience of industrial training was small, yet even among those with a good experience there was a call for improvements which mainly related to planning and the interpretation of college tutors and training officers of their roles. . The sandwich course structure had the advantage that basic training could be completed before the first academic period and so both illuminate and reinforce the possibility of integration with subsequent academic periods. Recent insights have suggested that the nature of integration was far from understood.

Qu. 11. Was there any evidence that industrial training produced different types of technologist to those produced by traditional three year course other than that to be expected?

No. The industrialists who were interviewed did not indicate that there were any differences. They looked for particular types of personality and drive. They wanted professional personnel who were high achieving and concerned with obtaining profit for the enterprise. They were not so much concerned with qualifications as they were with the ability to perform. Sandwich courses had the benefit of preparing students capable of working in industry immediately.

Questions 12 and 13 are considered together

Qu. 12. Was there any evidence to indicate that one structure of course (full-time – thick sandwich, thin sandwich) was better than another?

Qu. 13. Was the presumed shortage of qualified scientists and technologists sufficient to justify the colleges being required to run end-on sandwich courses?

Jahoda pointed out that asking students which type of course they preferred would lead them to justify the course they were on. It is extremely difficult to make comparisons with something you have not experienced, and there is a desire to justify your own choice [2]. Hornsby-Smith found that this was the case when he studied students following programmes for degrees and diplomas in metallurgy in a department which offered a full time degree, and thick and thin sandwich courses for the dip.tech [10].. By the end of the second session most of the students in the three differently structured courses *"indicated a preference for their own course, and there was no evidence for a consensus in favour of any one structure".* This was a striking example of cognitive dissonance which Jahoda had predicted would occur if students were directly asked which structure they preferred [2].

The only way to have resolved the problem would have been to have compared the relative performance of comparable cohorts on thin and end-on thin sandwich courses of which there were a few. Given the success of thin sandwich courses it is difficult to believe that there would have been any difference between the two, all things being equal.

There was much discussion in the colleges, but little of it was centred on the utilisation of college buildings. The concerns were mainly with teacher contact hours and conditions of service, and the length of time available for the academic periods. At the time, it seemed that despite the opposition to end-on courses, teachers would, given appropriate facilities and assurances as to holidays and vacations, operate certain types of end-on scheme, even though the debate was angry..

But, were end-on courses necessary? Heywood who obtained data from 143 of the 200 or so medium and large organisations supporting dip.tech courses obtained no evidence to support the view that these firms were generally short of qualified scientists and technologists [7]. There was some evidence of specific shortages. Overall the evidence did not indicate there would be a doubling of numbers if end-on arrangements were adopted, which was an important selling point.

Qu. 14. Did government policy influence the academic direction which these courses took?

Yes, in two ways. First, the declaration that dip.tech equalled degree undoubtedly influenced academics to ensure that their teaching mirrored that of the universities. Second, following the establishment of a Committee on Higher Education in 1961 to make recommendations about the future of higher education, debate about the status of the CATs and the dip.tech overshadowed all others in the colleges [8]. While the majority of staff favoured the acquisition of university status, there were some, who like the college principals thought the colleges should be given Royal Chartered status. In these circumstances it is not surprising that courses should mirror those offered in universities. The creation of the committee in 1961 was the critical incident that determined the fate of the NCTA.

Conclusion

This paper has described the rise and fall of a unique sub-system of education created specifically to educate technologists for manufacturing as opposed to R and D. As such it is historically unique. It was developed at a time when there was increasing demand for university education across the social class spectrum. It also came at a time when there was increasing research in higher education, and it became a topic of interest both to the Colleges as well as those seeking to do research in this area. From one perspective or another most of the components of the system were examined.

Unfortunately, the investigations were established by the colleges or individuals within them independently of each other. Nevertheless, it is possible to draw a picture of the whole. This paper has constrained itself by referring only to the results of those investigations. It did not refer to the two surveys on mathematics [16] and metallurgists [17] because the problem for students was as much about teaching as it was about content, and that continues to be the case.

Release the constraints and the picture is clarified. For example, other investigations showed that sixth formers had a poor image of engineering, and that the ‘A’ level grades of students seeking entry to engineering departments were lower than those for students seeking entry to science departments.

The colleges and their diplomas were regarded by the public as part of the technical college or vocational sector, and as such second class systems. That is the way the social class system in England and Wales functions. It was inevitable that the diplomas would imitate university degrees. They had to justify the claim that their programmes were equivalent to those degrees. In these circumstances the pressures against innovation were profound. Sufficient that they offered liberal studies, and better still, integrated industrial training which was well researched with implications that were far reaching.

The idea of the dip.tech course stemmed from the recommendations of the Percy Committee. They have been put to the test in the above analysis and found wanting. The students of the diploma courses were found in R and D departments and that is where half of them wanted to be. There is no evidence that a different kind of technologist was produced, and those responsible for the diplomas, resisted the demands of industry for an innovative curriculum, and end-on sandwich courses. They were a product of the culture which gave status to universities, and believed that engineers were applied scientists, hence the drive to include more science and mathematics in courses which is what R & D personnel were thought to require.

Today

The phrase "history does not repeat itself" is often used to persuade us that we have nothing to learn from history. Yet, it is very clear that we can learn from history about the mistakes that were made in the past, and not repeat them ourselves. It is also clear that history is a narrative about how societies deal with persistency in their own cultures.

In England the effects of social class on education persist. Just as they conditioned the outcomes of the dip.tech sub-system of technological education, so they continue to influence public attitudes to education. The academic continues to be preferred to the vocational as commentators and government have found. The symbolism portrayed by terms such as dip.tech and CAT could not escape the "social class" dimension. Identity, a concept that is currently the subject of much scrutiny in the *Journal of Engineering Education,* is closely related to the search for status. For example, engineering is often squeezed out of conversation by "science" on the one hand, and on the other hand "technology". It is no accident that the Institution of Electrical Engineers (IEE) should have changed its named to the Institution of Engineering and Technology when, in 2006, it merged with the Institution of Incorporated Engineers (IIP). The public, however, would hardly have appreciated that the IEE represented professionals and IIP technicians, or that in the United States, a degree in technology is a degree for higher level technicians.

History shows that the ability of the system to persist in spite of disruptive forces is considerable. Such forces are the increasing costs of higher education, and the rapidly changing structure of the work force. One way of reducing costs is to shorten the courses by either reducing content or compressing a three year programme into two; some of the 1992 universities in England are experimenting with the latter. If there is a lesson from this study it is that alternative structures, provided they are carefully managed, are likely to make very little difference to outcomes. But, if they are to spread, the leadership has to come from institutions with status willing to adopt them. Failing that only a government edict, allowing of no exemptions, would suffice.

Finally, these papers raise questions about the scope of engineering education research. Most of the participants were working in social science departments; several in pursuit of higher degrees. Given that the Percy and other official committees used the term technology (ist) to describe engineers, and given that the public may think in this way if they are not thinking about IT and smart phones, might not a better expression of the area be engineering and technology education research?

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References

[1]. J. Heywood, R. Ann Abel (eds) (1965) Technical Education and Training in the United Kingdom. Research in Progress 1962 – 64. Slough. National Foundation for Educational Research. Occasional Publication No 8.

[2] M. Jahoda (1963). *The Education of Technologists*. London. Tavistock. NFER Survey entries 15 and 16.

[3] P. Marris (1964). *The Experience of Higher Education*. London. Routledge. Kegan and Paul.

[4] J. Heywood, J. Pollitt and V. Mash (1966). The schools and technology. *Lancaster Studies in Higher Education,* 1, 153-305. (University of Lancaster).

[5] C. Heward, V. Mash and J. Heywood (1968). Student reaction to sandwich course for the Diploma in Technology (Dip. Tech*). International Journal of Electrical Engineering Education*, 7, 253 – 269.

[6] J. Heywood, V. Mash (1968) Secondary education and occupational choice of students on graduation from sandwich courses (dip.tech):pre-entry factors. *International Journal of Electrical Engineering Education* 6, 109 – 134.

[7] J. Heywood (1974). Trends in the supply and demand for qualified manpower in the sixties and seventies. *The Vocational Aspect of Education*, 26(64), 65 – 72.

[8] J. Heywood (1969). *An Evaluation of Certain Post-War Developments in Higher Education.* Thesis (Two Volumes). Lancaster, University of Lancaster.

[9] I. Hordley (1965). Entry 41 in Technical Education and Training in the United Kingdom. Research in Progress 1962 – 64. Slough. National Foundation for Educational Research. Occasional Publication No 8.

[10] M. P. Hornsby-Smith (1967). A study of three parallel degree level course in a Department of Metallurgy. *Lancaster Studies in Higher Education* No 2 (University of Lancaster). NFER Survey entry 44.

[11] H. Dickenson (1964). Students in a CAT: Qualifications and success. *Universities Quarterly*, 18, 407.

[12] B. J.Walmsley, A. W. Chisholm (1965) Summary of a report on the examination performance of diploma in technology students in the Department of Mechanical Engineering Salford CAT in relation to their Qualifications in Technical *Education and Training in the United Kingdom. Research in Progress 1962 –* 64. Slough. National Foundation for Educational Research. Occasional Publication No 8. NFER survey entry 17.

[13] G. N. Patchett (1967).Entrance requirements for degree courses and final course. *International Journal of Electrical Engineering Education*, 5, 707.

[14] J. Haslam, W. Hawkins (1965). Causes of failure in a Department of Electrical Engineering (dip. tech) at Woolwich Polytechnic. Cyclostyled report. See NFER Occasional Publication No 8. *Technical Education and Training in the United Kingdom. Research in Progress*. Slough, National Foundation for Educational Research. NFER Survey entry 117.

[15] C. Woods, (Christine Heward) (1965) Entry 22 in *Technical Education and Training in the United Kingdom. Research in Progress 1962 – 64*. Slough. National Foundation for Educational Research. Occasional Publication No 8.

[16] M. R.Scott et al (1966). *The Uses of Mathematics in the Electrical Industry*. London. Pitman (Based at Salford CAT). NFER Survey entry 65

[17] R. J. Clarke, (1967). Mathematics and Metallurgists. *Lancaster Studies in Higher Education* 2, B1 – B15. (Based at Birmingham CAT)

[18] G. F. Matthews "The effect of course structure on diploma in technology students". In NFER Occasional Publication No 8. *Technical Education and Training in the United Kingdom. Research in Progress*. Slough, National Foundation for Educational Research. Additional information provided in personal communications to this writer. NFER Survey entry 12.

[19] L Davies, (1965). *Liberal Studies and Higher Technology*. Cardiff, University of Wales Press.

[20] H. Andrews, C. Mares (1963). *Liberal Studies in Advanced Scientific and Technological Courses.* Report. Slough. National Foundation for Educational Research.

[21]. R.Peers, P. J Madgwick (1963). Problems and attitudes in higher technological Education. *The Vocational Aspect of Secondary and Further Education*. 15, 69 – 91.

[22] R. Rice (1965). A survey of the industrial work period of students of the Diploma in Technology at a College of Advanced Technology. *The Vocational Aspect of Education*, 17,

[23] D. Lee, I. Hordley (1966). Technical education: An alternative route. *Technical Education* 8, 394.

[24] G. S. Bosworth. Towards creative activity in engineering. *Universities Quarterly*, 17, 286, 1963.