

Technological Training—Education for Industry

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The invention of the steam engine and the widespread use of machinery in the rapidly growing manufacturing industries of the last century created the demand for a new form of training for those whose business it was to design, make and operate the new machinery. The rate of change was so rapid that it no longer gave the craftsman time to develop the forms and methods of construction by the time-consuming process of trial and error. The sciences of geometry, applied mechanics and physics had to be brought to the aid of the mechanic to accelerate the speed of engineering development and avoid the delays caused by traditional methods. The young mechanic sought instruction from the scholar and it is interesting to note the number of clergymen whose ability in mathematics led to their interesting themselves in the new developments.

Then again, physicists, chemists and mathematicians in the universities took an interest in many of the new inventions and helped to formulate the laws and principles underlying their operation. It is significant to note that in the last century the actual working invention often came first and the scientific explanation of its operation was explained later. Watt developed the steam engine long before Rankin and others explained fully its place in the theory of heat engines.

In England, in the middle of the last century, classes in the fundamental sciences of applied mathematics, geometry and physics began to be held in the Mechanics Institute and these helped to produce from ambitious local tradesmen the skilled mechanics and draughtsmen required by the engineering industries of their region. Eventually these classes were incorporated into the present system of State technical education.

In Ireland, the first venture of the State into this field was in 1889 when an Act was passed which gave urban or rural authorities permission to levy a rate not exceeding one penny in the pound to supply technical or manual instruction. It is interesting to note that the term "technical instruction" was defined as meaning "instruction in the principles of science and art applicable to industries and in the application of special branches of science and art to specific industries or employment." It was *not* to include teaching the practice of any trade or industry or employment. It was in 1899 that the foundations of our present system were really laid. It was in that year that the Government established the Department of Agriculture and Technical Instruction for Ireland and set the pattern which we follow to-day. Because of the previous experience of the

men who came to Dublin to set up the D.A.T.I. and because they worked in a virgin field they were able to build up an excellent system of technical education which penetrated the entire country and which still possesses advantages over the English system.

Technical schools were established in almost every town in the country, and to-day classes are available in Ireland in towns which were they situated in England, would still be without such amenities. The early association of technical education and agriculture would seem to have been primarily responsible for this.

The demands of the shipyards and the other industries of Belfast and region led to the building of the Belfast College of Technology or as it was then called, the Belfast Municipal Technical Institute, and it was formally opened on October 30th, 1907, by the Lord Lieutenant of Ireland, the Earl of Aberdeen. The foundation stone had been laid on November 24th, 1902, by the then Lord Lieutenant, the Earl of Dudley.

Though the demand for technical education arose from those employed in industry as mechanics it was inevitable that, as the level of instruction rose, the Universities should become interested, and Faculties of Engineering and of Applied Science began to appear, sometimes to the accompaniment of much opposition from the adherents of the classical tradition.

The subject of Engineering has of course been a feature of the activities of Queen's University since the earliest days of Queen's College, and Lord Kelvin's elder brother James was the second holder of the Chair. The work in this department has however been limited in effect to Civil Engineering and the rapid increase in the demand for scientifically trained Mechanical Engineers and the emergence of the new Electrical Engineer at the turn of the century found the University unprepared to undertake the task of building and staffing two new departments to meet this want.

Under the wise chairmanship of the late Sir James Henderson and with the guidance of Mr. Robert Blair, head of the D.A.T.I., the Technical Instruction Committee of the Belfast Corporation showed courage and enterprise in building, equipping and staffing the College of Technology. Great credit is due to those who saw the possibilities of collaboration between the University and the city in providing higher technical training for young people in this comparatively small corner of the United Kingdom, and the scheme of co-ordination which was worked out between these two bodies has been greatly to the advantage of each and can be taken as a model by other communities similarly placed.

In 1910 the first scheme took form and it was made possible for students of the University to take degrees in Mechanical or Electrical Engineering. This was done by making use of the staff and teaching facilities of the College of Technology for the specialist instruction in engineering subjects and, with the help of the mathematics and science departments of the University, students were enabled to graduate in the Faculty of Science.

Experience of these arrangements was so encouraging that the scheme was widened in 1921 and a new faculty, the Faculty of Applied Science and Technology, was created. This was housed entirely

in the College of Technology and the subjects for the degree included Mechanical and Electrical Engineering, Pharmaceutics, Applied Chemistry and Textiles. The ancillary subjects such as Mathematics and Physics were now taught in the College of Technology and the University assured itself of the qualifications of teachers before conferring on them the titles of Extra-Mural Professors, Lecturers or Teachers.

All the expenses of teaching were borne by the Belfast Corporation with the normal grants from the Ministry of Education. The University was thus enabled to apply its dignity and authority to meeting a great need of the community in this important branch of technological education before public and government opinion had been made aware of the necessity for ensuring its direct financial support for this purpose.

While University students were benefiting by having this form of education provided in their own city, the engineering apprentices and other non-University students also had the advantage of having at their service highly qualified staff and well equipped laboratories whose provision could not have been justified but for the presence of the University classes.

The provision of higher technological education is a very costly business and it is fortunate that we in Northern Ireland learned so early the advantages of co-operation in this field. The importance of the University to the prosperity and indeed to the very survival of the country was clearly demonstrated during the last war and has convinced the government of the importance of providing adequately for its support. It is good to see that in their immediate plans for expansion the University and the Corporation intend to use government assistance to continue their partnership and thus reach a level of performance which would be beyond the reach of each separately.

As has been said the tremendous part which the Universities and technical colleges were called upon to play during the last war brought home to the governments, not only of the U.K. but also of all the other powers, the necessity of maintaining the institutions in a sound and efficient manner, and of making the best possible use in war and peace of the most precious asset of any country, the brains of its people. The struggle between the German-Japanese alliance on one hand, the British-American partnership on the other, was so delicately balanced that one could have been justified in saying that the fate of the nations might have lain in the hands—or rather in the brain—of one man. The turning point of the war against the submarine was the development of very short wave radar. This was primarily the work of a research team at Birmingham University, and had success been delayed for a further year the submarine packs might have brought this country to its knees. Again the timely development of the proximity fuse for anti-aircraft guns gave the American navy the mastery over the Japanese suicide bombers which were being used with such deadly effect against the American aircraft carriers.

Not so dramatic, but nevertheless very effective, was the work of the College of Technology during the war. In addition to the normal production of engineering graduates and the training of engineering

apprentices, several special training schemes were instituted by the government. From the pass lists of the senior certificate examination students obtaining distinctions in two or more of the subjects of Advanced Mathematics, Physics and Chemistry were offered special Bursaries and received accelerated degree courses in engineering or chemistry so that they could be used in the advanced technical arms of the services or in government or industrial research. In view of opinions which have received prominence lately, it is interesting to note that the government made no distinction between the sexes in this case and that though boys were in the majority, as might be expected in these subjects, quite a few girls were awarded bursaries, completed their courses of study and were employed in various industrial research projects.

At a slightly lower level of academic attainment boys were selected for intensive six months' courses in engineering and science, the better to fit them for commission in technical branches of the forces. It is interesting to note that through the operation of conscription boys were brought to study at the College of Technology from practically every public school in the British Isles, and that some of them came back to complete the degree course of Queen's University when they might have been expected to choose an English or Scottish University.

Still another cadetship course was formed to supply junior officers for the newly created Corps of Royal Electrical and Mechanical Engineers. These boys were recruited from the schools of Northern Ireland and given a comprehensive course of training in engineering subjects lasting for a minimum period of 21 months. The first two commissions to R E M E from this scheme went to boys from Northern Ireland to be closely followed by a class from Northampton Polytechnic in London.

It is not surprising after this experience that when the war ended the British government through the University Grants Committee stepped up its support of the universities, especially for work in science and technology. The Northern Ireland Government decided to give greater assistance to Queen's University and for the first time made use of the services of the University Grants Committee in an advisory capacity.

The Universities are very jealous of their academic freedom and the government recognises the value of keeping the direction of university policy outside politics and to this end has set up the body known as the University Grants Committee to disburse the money which the Treasury makes available for all the universities of the country. The committee, composed of scholars and administrators, many of them university professors, visit all the universities of the country at five yearly intervals and examine their plans and estimates for development. On their recommendations the Treasury makes the money available and limits its own decisions solely to the magnitude of the total sum involved. In this way the development of any one university is influenced only by the U.C.G. and not by government. Of course the overall policy of the government with respect to the universities is influenced by the return which it sees it is getting for its investment and Parliament is each year taking a keener interest in university affairs. It seems

inevitable that with more and more public money going into universities in the shape of U.G.C. grants and local government awards to students, closer government control of policy is inescapable

In the case of Northern Ireland, grants to university authorities are made directly by the Ministry of Finance, but the use of the offices of the U.G.C. is an assurance to the government that the scale of its contribution is such as would be given by the Imperial Government to an English University, and that the new buildings and courses proposed are in fact necessary for the well-being of our province

After the war when it became obvious that the government would have to assist Queen's University directly, some difficulty arose as to how this might be done, remembering that, for precisely the same kind of staff, buildings and equipment, the Belfast Corporation would also be seeking grants through the normal machinery of the Ministry of Education. The success which had attended the earlier solution of this sort of problem gave the clue to the course to be followed, and after a series of joint meetings between representatives of the university and the Corporation, a scheme was put up to the government which led to the passing in 1954 of the Act of Parliament which set up the Joint Authority for Higher Technological Studies

The Joint Authority for Higher Technological Studies is composed of eight members, four representing the Senate of Queen's University and four representing the Belfast Corporation. The chairmanship is to alternate annually between representatives of these two bodies. The Joint Authority will be responsible for the new building which it is proposed to erect on the Stranmillis site immediately adjoining the new Civil Engineering and Chemistry building

So that the machinery of the University Grants Committee may be used for the building and equipping of this new establishment, the government on the advice of that committee, will pay to the university the full cost of its erection and when completed the premises will be vested in the Joint Authority at such a rent as will cover any expense the university may have incurred. The building will then be put equally and independently at the service of the university and of the Corporation, each body to be solely responsible for the teaching of the students which it sends there. The Joint Authority has no concern with teaching but is charged only with the maintenance of the building and its equipment and for providing the necessary services and staff to ensure that it is maintained for use by the teaching staffs provided by the University or the Corporation

Each of these two bodies will enrol its own students and will collect their fees. The expenses of the Joint Authority will be met by contributions from the University and the Corporation, the proportion to be decided by the Joint Authority on the basis of the use made by each of the building as decided by some such yardstick as student hours, class hours or any other agreed method. The amount so levied shall be binding on both bodies.

Provision has also been made for the employment, where desirable, of University staff to teach Corporation students and of Corporation staff to teach university students, each body to pay the necessary proportion of the salaries of the teachers so employed. It is hoped in this way to secure the greatest possible flexibility in the use of staff

and equipment and to enable highly qualified specialists to be recruited

It is difficult to forecast the numbers and type of the students who will use the new Joint Authority building, but our plans in the first instance are based on the assumption that it will be used equally by university and non-university students. These latter will be working for Higher National Certificate and Sandwich Course College Diplomas.

It is interesting to note the changes which have taken place through the years in the organisation of technical education. In the beginning instruction was sought for its own sake in such subjects as Applied Mathematics, Heat Engines or Machine Design. Then certificates from colleges certifying that students had attended courses and passed examinations in various engineering subjects were sought and began to have currency value in engineering firms. The necessity for achieving some degree of uniformity among colleges and of grouping individual subjects to form a balanced course required the assistance of some national body, and it was in the British tradition that this was not attempted by the government directly but by the City and Guilds of London Institute. This body, with the assistance of many regional and national committees composed largely of technical representatives from the industries concerned, built up examination schemes for all the major industries of the United Kingdom and these examinations, conducted simultaneously all over the country, had a very big influence on the development of the technical colleges.

However the very degree of success achieved by this scheme indicated the need for a new system in some of the more highly organised industries. The City and Guilds examinations were of necessity external, and when the level of instruction began to approach that of the universities, attention was naturally directed to the advantages which the universities possessed in having internal examinations, the national standard of which was maintained by the appointment of external examiners.

Just over thirty years ago a scheme was evolved for the award of National Certificates in Mechanical Engineering for students attending technical colleges while currently employed in the engineering industry. This scheme is administered jointly by the Ministry of Education and the Institution of Mechanical Engineers. It has, from its inception, been outstandingly successful and has had a profound influence on the education of young people in the engineering industry.

The scheme has been successful because the experience of industry has been brought to the assistance of the Ministry of Education and the Colleges, through the Membership of the Institution of Mechanical Engineers and many of the advantages of the university examination system have been incorporated by having each of the colleges conduct its own intermediate examination and also the final examinations, subject to assessment of papers and marking schemes and review of the worked scripts by experience assessors appointed by the Institution.

Unlike the City and Guilds awards, National Certificates are not given solely for the passing of examinations but also require evidence of a minimum number of hours of attendance in each subject and the satisfactory performance of laboratory experiments and of homework. To gain the Ordinary National Certificate a student must have attended

about $7\frac{1}{2}$ hours per week for three years and the Higher National Certificate, which closely approaches degree level in its three final subjects, is given for a further two years of attendance. In 1955 there were 7,674 Ordinary and 3,212 Higher National Certificates given in the United Kingdom. The figures for Northern Ireland were 128 and 26 respectively. National Certificate schemes are also operated by the Institutions of Electrical Engineers, of Production Engineers, of Naval Architects and by the Royal Institute of Chemistry.

Though the National Certificate scheme took over the leadership from the City and Guilds in so far as education for the engineering industry is concerned, the latter body still has an important part to play in some specialist branches of engineering education and is pre-eminent in many of the manufacturing industries. It would seem that the time is now ripe for a new authority to take over the leadership from the National Certificate scheme in Engineering education, though the latter awards will continue to play an important part and will increase in number.

The rapid advances in engineering technology are making heavy demands on the technical education of young people in industry and it is becoming impossible to find enough hours of instruction in the part-time system to reach the higher standards required. This has been evident to many for some time but the need for a change has been temporarily averted by the increasing amount of day release given to apprentices in the engineering industry. The government, keenly aware of the necessity for matching the efforts of other countries, has endeavoured by means of scholarships and grants, to increase the number of young men pursuing degree courses in engineering at British universities but although there has been an increase since the war it is not as great as was expected and attention has been turned to the possibility, not of increasing the number of ordinary university graduates, but of tapping the vast field of apprentice training and of intercepting the best of the prospective Higher National Certificate candidates and giving them what is in effect a university type course.

Under the chairmanship of Lord Haves, C.H., M.B.E., D.Sc., LL.D., The National Council for Technological Awards was set up in 1956 and it is the intention of this body to award diplomas in technology to students who pursue courses of study of university standard in some of the Technical Colleges whose equipment is suitable and whose staff is well fitted for this work. The young men undergoing this form of training will be apprentices in industry and will spend alternate periods of six months at college and in works. At the end of the four year course they will have covered the same ground as in an honours degree course, and if successful in their examinations will receive the diploma of the National Council which will be written "Dip. Tech." and will, it is hoped, immediately gain the recognition in industry and in society that is at present enjoyed by the B.Sc.

I have tried to trace the growth of our system of technical education, largely for the engineering industry, and have shown how it has grown and changed its character to meet the social and industrial changes which have taken place in this country. It should now be obvious how difficult it would be to attempt a statistical comparison between the output of professionally trained engineers in the United

Kingdom and in other countries. Social conditions vary so much that such a comparison is well nigh impossible. It is interesting to note that, though the U.S.A. in its educational system and its industrial structure generally enjoys the reputation of extreme liberalism and democracy, the professional engineering class there has stratified to a far greater extent than is the case in this country. A few years ago figures showed that 93% of the members of the American Society of Mechanical Engineers held university degrees. In the United Kingdom more than half of the members of the Institution of Mechanical Engineers had been originally trade apprentices and had achieved professional status through part-time classes and the Higher National Certificate.

Notwithstanding the difficulties of comparison we are repeatedly confronted by statistics giving the numbers of qualified engineers being produced annually in America, Germany, Russia and the U.K. The comparison usually is, and is meant to be, startling. As far as America is concerned, figures of a similar order could have been produced before the war and if they had been truly representative of our respective engineering industries it would be difficult to account for the very fine record of achievement of this country during and since the war in the field of engineering. The reason why these figures do not give the whole picture may be gathered from a statement made in the preceding paragraph that half of the Corporate Members of the Institution of Mechanical Engineers came from the ranks of engineering trade apprentices. Last year over 3,000 Higher National Certificates in Mechanical Engineering were awarded in the U.K. A comparable figure was also applicable to Electrical Engineering. In many statistical comparisons these young men are not counted since they represent a class which is not generally to be found in other countries and a comparison limited to holders of university degrees is misleading. But that is not the whole story and it would not be a sufficient explanation to count the holders of Higher National Certificates in our statistics. The Higher National Certificate courses being part of a voluntary, part-time scheme, superimposed on an existing and long recognised form of apprenticeship training, have almost of necessity a high wastage figure throughout the arduous training period. The extent of this may be gauged from the figures of 7,600 Ordinary National Certificates to produce the 3,200 Higher National Certificates. The wastage figure assumed for a degree course may be 20% but this figure of 58% which we have obtained for part of the Higher National Certificate course is not wastage to the same extent for we have examined only a part of their training and many of those who fail to obtain the Higher National Certificate and be included in our statistics, are in fact doing work which in other countries might be done by the holders of a pass degree.

All this is not to say that we have any reason to be complacent. Much information has been brought back to us about the form being taken by the higher engineering educational institutions in Russia. Leaving aside for a moment the question of the volume of the national effort there, everything goes to show that in quality of work the Russians are forging ahead rapidly and we have much to learn from them. A totalitarian régime can throw great weight into any branch

of the national effort, and we have long been aware of the emphasis which the Russians place on the teaching of the young. Having made comparatively secure the social and political education of the children, it seems that they are now applying themselves with great thoroughness to building up a scientific and technological training structure, which has been much admired by all who have been privileged to examine it. It is bound to possess traces of the weakness of any totalitarian system, but our latest information would seem to show that the very able men teaching in institutes of advanced technology are accorded a greater degree of freedom than may be shown to other employees of the state. Their salaries are also much higher in comparison with colleagues in industry than is the case in this country.

We are accustomed to reading of British inventions which are taken up, developed and produced in America, to the great advantage of that country in financial reward and national prestige. It would seem to be true that we in this country are more interested in fundamental engineering design than in the details of manufacture or the scientific approach to management and design for production. There is evidence since the war that we have become aware of the need for a new approach to this problem, and efforts are being made to convince the younger workers that there is just as great a demand for advanced technological training on the shop floor as in the designing department.

With the help of Counterpart Aid Funds from the USA the Committee of the Belfast College of Technology, a year ago, seconded three members of staff for a year to attend courses in industry and in technical colleges in England and Scotland in the field of management studies. It is difficult to convince many firms of the great need for treating management as a subject for study in a technical college or university. It is not a subject which can be taken by young men before entering employment, as many other subjects can, but it can only be taught to men who have had sufficient experience in industry to appreciate the nature of the problems and to be able to use judgment in considering the solutions offered.

It can thus be seen that students for much of the work that has to be done in the field of management studies cannot come as individuals, of their own choice, but must be selected by their employers as suitable by personality, ability and experience for further training, and must generally be sent in the firm's time for courses which may last anything from a week-end to a college session. This would seem to make these very expensive to firms, but experience has been accumulated in America and in this country, which ought to convince the most sceptical of the value which is to be obtained from courses of this kind.

Bearing in mind the age and experience of the students and the nature of the subject, it is realised that the usual college classroom form of instruction is quite unsuitable. The atmosphere in which the most successful classes and conferences have been conducted has been that of the guided discussion group meeting in a comfortably furnished club room. The Belfast Education Committee has obtained premises of this type which it is proposed shall be opened shortly by the College of Technology. In it will be held various courses in management subjects for employers, technical staffs and Trades Unions officials. The College has available suitably qualified members of

staff with experience in commerce and in the fields of engineering and the textile industry and visiting lecturers will be engaged. Already full-time classes of two month's duration have been conducted in the main college buildings for representatives of a varied cross section of our local industries. Their particular field of study was the subject of "Work Study" and the results obtained have been encouraging.