TECHNICAL EDUCATION.

ADDRESS

DELIVERED BY

PROFESSOR GALBRAITH

AT THE OPENING OF THE

ENGINEERING LABORATORY OF THE SCHOOL OF PRACTICAL SCIENCE, TORONTO, FEBRUARY 24TH, 1892.

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MR. CHAIRMAN, LADIES AND GENTLEMEN :—

The subject of the paper which I propose to read this evening is "Technical Education."

In selecting this subject I was influenced not only by its appropriateness to the occasion, but also by the fact, as it appears to me, that there is more or less vagueness in the public mind as to its objects and methods.

The word technical is derived from the Greek τέχνη, an art, handicraft or trade. The idea involved in this word is the bringing forth or making of material things as distinguished from thoughts and mental images. It is not always safe, as you know, to infer the modern meaning of a word from its derivation. Nevertheless it happens that one of the great branches of technical education, as at present understood, is exactly defined by the old Greek word, namely the training of apprentices in the arts and handicrafts. Technical education in this sense has been in existence since the days of Tubal Cain, the instructor of every artificer in brass and iron ; and to it we owe the greater part of the material progress which has been made since the world began.

In these latter days, however, a new application has been found for the term. In consequence of the growing competition for trade among civilized nations, and the recognition of the relations of art and science to production, schools for giving artistic and scientific training to those engaged in industrial pursuits are becoming acknowledged as one of the necessities of modern times. These are known as technical art schools and technical science schools. It is to the latter alone that I propose to direct your attention this evening.

From the time of the revival of learning in the middle ages down to the present century the energies of the universities and schools have been directed in channels having little or no connection with the material necessities of civilized beings. The sole exception has been the schools of medicine. That this should have been so may seem strange, but it appears to me that we have not far to go for the explanation.

The universities and schools are not the originators of knowledge. They are simply collectors and distributors. Natural science is a thing of modern growth. It had to reach a certain stage of development before the community could become interested in it; and not until a demand for scientific knowledge had been created could it be admitted into schools of learning. How long, for example, is it since the physical sciences have been made a part of our Ontario school curriculum.

Herbert Spencer, in an essay on Education, says :—" That which our " school courses leave almost entirely out we thus find to be that which " most nearly concerns the business of life—all our industries would " cease were it not for that information which men begin to acquire as " they best may after their education is said to be finished. And were " it not for this information, that has been from age to age accumulated " and spread by unofficial means, these industries would never have ex- " isted. Had there been no teaching but such as is given in our public " schools, England would now be what it was in feudal times. That " increasing acquaintance with the laws of phenomena, which has " through successive ages enabled us to subjugate nature to our needs, " and in these days gives the common laborer comforts which, a few " centuries ago, kings could not purchase, is scarcely in any degree owed " to the appointed means of instructing our youth. The vital knowledge, " that by which we have grown as a nation to what we are and which " now underlies our whole existence is a knowledge that has got itself " taught in nooks and corners, while the ordained agencies for teaching " have been mumbling little else but dead formulas."

It seems to me that these words of Spencer should be taken rather as an indictment of the community than of the schools There has been, and may yet be to some extent, opposition on the part of men permeated with the older culture to the introduction of the physical sciences into the schools, but this opposition is disappearing as the sciences grow and prove their fitness for a place in the educational system.

One of the main obstacles to the introduction of the teaching of science, even after its importance had been fully recognized, was the large outlay required for the necessary apparatus. Scientific investigation is both qualitative and quantitative. The teaching of science on the qualitative side consists in the enunciation and illustration of principles. The apparatus required for this purpose is comparatively inexpensive, and may be improvised to a great extent by the teacher. In many cases no apparatus at all is required—simple observation of natural phenomena being sufficient. The case is altogether different when the principles of science are to be investigated quantitatively. Instruments for making precise observations and measurements must be used. These instruments are expensive and cannot be made by teacher or student. The highest mechanical skill is required for their manufacture, and patience, time and opportunity for their use. Laboratories have to be equipped, and the whole time of teacher and student given up to work with the hand, eye and ear.

It is not to be wondered at, that the introduction of science into the curriculum has been slow. Now that it has been accomplished the question naturally arises, Wherein exists the special necessity for the establishment of technical scientific schools? I think it may be answered thus:

In all schools for the teaching of professions and callings, whether we choose to consider them technical or not, it is an admitted necessity that the teachers should be practical men in such professions and occupations. What would be thought of a medical school in which the teachers were not physicians? of a law or divinity school in which they were not lawyers and theologians? In like manner the teachers in technical schools should be engineers, architects, manufacturers, artizans, miners and agriculturists if it is possible to get them. The difficulty which exists at present to a large extent, but which will disappear with the progress of technical education, is that there are very few men in the above professions and occupations who have had a sufficient training in science to make them successful teachers—their knowledge is practical, not scientific. The teacher in a technical school should be more or less acquainted with the various trades—with the methods in vogue for handling and transforming material. He should know how things are done and made in actual life and on the commercial scale.

He ought to have a better perspective, so to speak, than the purely scientific man in reference to the needs of his students, and should be able to meet them more nearly on their own plane, and interest them in science by selecting his illustrations from their work, actual or prospective. It is of the first importance that he should keep himself informed in the latest manufacturing processes. This cannot be done by reading. The text-books are always years behind the times in this respect. Manufacturing and engineering periodicals are better, but still they convey little or no idea of the scale on which work is done. Personal observation, travel, and engaging in outside work whenever possible are the only methods whereby the teachers in technical schools can gather the proper material for illustrating scientific principles and maintaining the interest of students in their work.

The principal work of a technical school is the teaching of science and not, as many suppose, to turn out fully fledged engineers, architects, manufacturers and tradesmen ; all that it can pretend to do is to turn out partially educated men. The graduates must supplement the work in the school by practical experience in after life before they acquire the right to call themselves practical men.

The practical work of the school differs in many respects from the practical work of actual life. Where it is work of the same kind, as for instance, drawing, designing, the use of surveying instruments, lathework, smith work, etc., yet the feeling of reality and responsibility is lacking. It is a very different thing to make mistakes in school work from making mistakes in similar work in actual life. A man is vastly more impressed by the necessary punishment which follows mistakes in the serious business of life than he can be by the arbitrary penalties instituted by the faculty.

Again there is a great body of knowledge necessary to complete a man's practical education which it would be only an utter loss of time to attempt to give in a school, simply because there are no well-defined threads of scientific thought upon which to string it. Three-quarters of the information to be found in an engineers' hand-book would be useless in the curriculum, although all-important in practice. Such knowledge becomes useful only when impressed by experience.

The establishment of engineering laboratories marks a new departure in technical education. Surely it will be said, the work in these laboratories is practical. So it is, but not perhaps in the sense in which the question is put. The steam engine in an engineering laboratory is not used for the same purpose as the factory engine. In the shop it is used for manufacturing purposes; it is placed in the laboratory for the purpose of being experimented upon. In the laboratory it is tried at different speeds, worked condensing and non-condensing, with varying steam pressures, with and without steam-jacketing, with different amounts of lead and cushioning, with different counterbalances for crank and connecting-rod, with varying clearances, with simple and multiple expansion. The work done at the main shaft is accurately measured; likewise the work in the cylinder—the feed water and condensing water are weighed—the degree of dryness of the steam determined. In short, in the laboratory all the conditions which may affect actual practice are experimentally investigated. It is only in this way that the principles governing the construction and action of engines can be fully determined.

What would an employer do with a man who should attempt any such work with the factory engine? He would simply give him to understand that his usefulness was gone, and that he had better look for employment at the School of Practical Science.

Again, since the teaching of principles is the main object of a school of applied science, it seldom happens to be useful to complete any of what is ordinarily called practical work, as would be necessary in actual life. To do so would occupy too much time. Practical constructions involve so many and various considerations and methods, that the attempt to complete them would simply be reverting to the old state of affairs when the apprentice gained his knowledge altogether on actual work. The study of the sciences would be so much interrupted and confused by such a method as to be of very little value. The practical work of a technical school in so far as it is of the same kind as that of after life must be selected and pursued rather as illustrating the principles of the special science under consideration than for the sake of the work itself.

In practical life, on the other hand, the result is the thing aimed at, and it matters nothing to those who pay for this result how it was arrived at, whether by rule of thumb or by the application of scientific principles. The work of the school is more analytic than synthetic, more destructive than constructive. The student pulls, as it were, machines to pieces in order that in after life he may learn to put them together. His proper work is investigation and experiment. After he graduates, his work on the contrary is construction and design. It would not be advisable to give equal prominence to both kinds of work in the school. The time is too short and the feeling of responsibility which should govern construction and design is absent and cannot be artificially excited. Make-believe work is essentially false and unscientific.

The arrangement of the courses of study in the School of Practical Science is in accordance with these principles. The departments of instruction are civil, mining, sanitary, mechanical and electrical engineering—architecture, analytical and applied chemistry, and mineralogy and geology.

In addition to the instruction given in the school the students take such work in the University of Toronto as is necessary. The university work is mathematics, physics and chemistry. Up to the present session mineralogy and geology have also been taken in the university. The greater part of this work will henceforth be taken in the school.

Through the exertions of the Hon. the Minister of Education and the liberality of the Provincial Legislature an engineering laboratory has been established and is now approaching completion. The Dominion government have also contributed their quota by relieving the school from the payment of customs duties on such apparatus and machinery as it was found necessary to import from abroad.

It may be of interest to you to have a short description of the main features of this laboratory.

It consists of three departments: First, the department for testing materials of construction. Second, the department for investigating the principles governing the applications of power. This department is subdivided into the steam laboratory, the hydraulic laboratory and the electrical laboratory.

The third department may be termed a geodetic and astronomical laboratory, as the work to be done in it, which relates principally to standards of length and time, is of special importance in these sciences.

In order to prepare specimens for the testing machines a shop has been fitted up with a number of high-class machine tools specially suited for reducing the specimens to the requisite shapes and dimensions with a minimum of hand labor. It is also fitted with the necessary appliances for making ordinary repairs.

The machines in the department for testing materials are the following:—

An Emery 50-ton mach. .e built by Wm. Sellers & Co., of Philadelphia, for making tests in tension and compression.

A Riehle 100-ton machine for making tests in tension, compression, shearing and cross-breaking. It will take in posts twelve feet long and beams up to eighteen feet in length.

An Olsen torsion machine for testing the strength and elasticity of shafting. This machine will twist shafts up to sixteen feet in length and two inches in diameter.

The last machine in this department is a Riehle 2,000 lbs. cement testing machine. The cement testing laboratory is fitted with the usual accessories.

These machines are all of the latest and most improved designs, and with the exception of the cement machine there are at present no duplicates of them in existence.

In the power department there are under the division steam, two boilers, a Babcock & Wilcox 52 horse-power and a Harrison-Wharton 12 horse-power boiler. The engine is a 50 horse-power Brown automatic cut-off engine built by the Polson Iron Works Co., Toronto, specially for experimental purposes. It is steam jacketted and has three alternative exhausts, to the open air, to a jet condenser and to a Wheeler surface condenser kindly presented to the school by Mr. F. M. Wheeler, of New York, the inventor. There are also a Blake circulating pump, a Knowles air pump and a Blake feed pump, the latter of which was a gift from the manufacturers. The engine is arranged so that it may be compounded when there are funds for the purpose. To have built the engine compound in the first place was deemed inadvisable as the money was urgently needed for other work.

A machine now being constructed by the Riehle Bros., of Philadelphia for measuring journal friction and testing lubricants, will shortly be placed in position. It is fitted with an ordinary railway car journal and box. The maximum loads occurring in practice can be applied. The maximum speed will be 50 miles an hour. This machine is expected to be an improvement upon any yet built for a similar purpose. I received a letter a few days ago from a railway in the Western States which intends to order one if we give a satisfactory report.

The hydraulic division of the laboratory is furnished with a three throw pump with double acting cylinders, built specially for the school by Northey & Co., of Toronto. It has adjustable strokes and has a maximum capacity of half a million gallons per day. It has been designed to produce an extremely steady pressure, this being requisite for hydraulic experiments. The maximum head under which it works is 230 feet. There will be practically no addition to the running expenses of the laboratory due to the working of this pump as the same water will be used over and over again, and the power will be furnished by the experimental engine. In order to make engine experiments the coal has to be burned in any case and the necessary resistance supplied either by a brake or otherwise. Driving the pump is one method of doing this. A three feet turbine wheel of the jet type built by the Fensom Elevator Co., of Toronto, forms a part of the same equipment. The pump furnishes the power for this wheel. There are two large tanks built by the Doty Engine Co., of Toronto, for experiments on the discharge of water through orifices and over weirs.

The above apparatus is arranged with a view to testing water meters, measuring the discharge of fire streams and various other hydraulic investigations within the capacity of the plant.

The electrical division of the laboratory is equipped with the following dynamos :—

Edison, Ball, Thomson-Houston, two Gülcher machines and a Westinghouse alternator with transformers, a Crocker-Wheeler, and a Kay motor, also two small fan motors.

There are in connection with it a Roberts storage battery, a gravity primary battery and a fair equipment of lamps, arc and incandescent, of different types.

The power department is equipped with the usual measuring instruments, indicators, gauges, gauge testing apparatus, scales, brakes, dynamometers, ammeters, voltmeters, resistances, galvanometers, etc.

In the geodetic and astronomical department are 100 feet and 66 feet standard of length—a 10 feet Rogers comparator with graduating attachment—a Howard astronomical clock and electro-chronograph—a Troughton & Simms 10 inch theodolite and all the ordinary surveying instruments.

That you may not leave this building to-night under the mistaken impression that our equipment is complete, and that we can spend no more money, I propose to conclude this paper by touching upon some of our most pressing wants.

The department of architecture has recently been established and is provided with a good collection of photographs and drawings. A large number of casts, models and plates will be required however to complete the equipment.

The oldest laboratory in the school is that in the department of analytical and applied chemistry. It is well equipped for general work in qualitative and quantitative analysis; also for the quantitative analysis of food, air, water, fuels and illuminating gas. Special apparatus is now urgently needed for the analysis of iron, steel, and other materials of construction to supplement the testing work of the engineering laboratory.

The important department of mineralogy, assaying and mining has at present a very meagre laboratory equipment. In view of the interest which is now being taken in Canadian mining, it is to be hoped that this state of affairs will be immediately improved, and that the School of Practical Science may be enabled during the next session to offer to those who may desire it, a complete course of instruction in mining engineering and metallurgy.

In sanitary engineering we have at present no special laboratory. Our hydraulic plant can be utilized largely in connection with this department, but in addition a collection of models is very necessary for purposes of illustration.

As cities increase and population grows denser, sanitary problems become more complicated and have to be dealt with by communities and governments instead of depending on individual action. As a consequence, sanitary engineering is becoming a most important branch of the profession, and a prominent position should be assigned to it in the curriculum of a technical school.

The rapid development of electrical lighting is bringing into prominence the question of the measurement of the illuminating power of electric lights. Special difficulties surround this problem, and it is desirable that our electrical laboratory should be furnished with the means for making such investigations.

It would greatly facilitate the work of the school in all departments to have means for making photographic lantern slides. Ordinary charts and maps soon grow out of date and take up a large amount of room. A photographic outfit would give the means of making lantern-slides of all the latest illustrations of machinery and construction that are published in engineering, manufacturing and architectural journals and of exhibiting them to large classes.

Another pressing want is a good technical library. If it were not for our periodicals, we should have no library at all; and while the Toronto Public Library has a good collection of works on technical subjects, yet they are for all practical purposes beyond the reach of our students.

Collections of rocks, minerals and products illustrating various stages of manufacturing are very much needed in the departments of mining and applied chemistry.

In view of these pressing demands the question will naturally arise, What is to be the outcome of this technical education—where are the young men to find employment? If the country cannot support them, what justification can there be for the expenditure? It seems to me that this is a question in political economy and might properly be referred to the distinguished head of that department in the University of Toronto or to our friends the Trades and Labour Council.

My answer can be only vague and general. I would reply by asking why we have gone into debt for the purpose of building canals and railways, docks and harbors—why have we built expensive houses of parliament, churches and jails, sewers and water-works, colleges and poor-houses? Is it not because we feel that we are as good as our brothers across the sea or as our cousins south of the lakes—are we not a civilized people, and have we not a right to these luxuries whether we can pay for them or not? Is it not as useful to the country to turn out men educated as engineers, architects, mechanics, miners and farmers as to turn out lawyers, doctors, ministers and bankers? Will not the graduates of our technical schools have that very education which our mechanics, artisans and tradesmen of all classes most desire, and of the necessity for which they are reminded every hour? If you had seen with me the crowd of eager men, young and old, who assembled the other evening at the opening of the Toronto Technical School, you would no longer have any doubt as to the desirability and necessity of technical education. If the country cannot support such men, so much the worse for the country, and so much the better for that country in which they find employment.

If we are ever to pay off our foreign debt and trade on equal terms with other nations, we must develope our material resources with economy and skill, and among the means making towards this end not the least promising is Technical Education.