SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, JULY 22, 1904.

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MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

*DOES A TECHNICAL COURSE EDUCATE?**

BEFORE we can answer the question 'Does a Technical Course Educate?' it is necessary that we understand what education should mean. We do not need to trace this word back to its root, to find its derivation in some ancient language and to learn its exact meaning in that tongue, but rather to find what it has stood for in the thoughts of men, what processes have been necessary to produce it and what its value has been to those possessing it. If we take a brief look at some of the methods and ideals of education in the past we may receive light upon its proper meaning to-day. Education is for the benefit of the individual or for the benefit of the state. In Persia, in Egypt, in Greece, in Rome, the individual was nothing, the state was everything. The hopes, the desires, the wishes of men were not considered; the growth and prosperity of the state were paramount. In Persia and Sparta education was for war. The education of the body was for the many; the education of the mind for the few. Aristotle was the first to teach that the ultimate end of education is the ability to enjoy the blessings of peace.

Society derives its ideals of education at any epoch from the limits of knowledge at that epoch. A man can teach only what he knows. If he knows but little he can teach but little; if the sum of human knowledge is small, there is but little to be taught, although there is much to learn. In the early days of Greece the Trivium and the Quadrivium embraced all knowl-

* Inaugural address of the president of Case School of Applied Science, May 11, 1904.

edge. Grammar, rhetoric and dialectics were taught to all who entered the schools; arithmetic, geometry, astronomy and music were reserved for the more advanced, who were few in number. The former were language studies; it was understood then as now that language, one's own language, is the most important subject for the beginner to study. It is a significant fact that the Greeks studied no language but their own. In Rome, too, all knowledge was found in the Trivium. Having little else to study, the Greeks and Romans each built up a language and a literature which have never been surpassed, the former for its scientific accuracy, the latter for the beauty of its thought and the elegance of its diction. The sciences of the Quadrivium were slowly developed by the Greeks, the Romans and the Arabs, and in the case of geometry and music were brought to a high degree of perfection. But science in these early as in later days met with much opposition from those whose chief study was language or philosophy. Socrates believed that the study of science was profitless and wrong, 'for he did not think that such matters were discoverable by men, nor did he believe that those acted dutifully towards the gods who searched into things that they did not wish to make known.' Locke must have been reading Socrates when two thousand years later in his 'Thoughts on Education' he said: "Natural philosophy as a speculative science, I imagine we have none, and perhaps I may think I have reason to say we never shall be able to make a science of it. The works of nature are contrived by a Wisdom and operate by ways too far surpassing our faculties to discover or capacities to conceive, for us ever to be able to reduce them to a science." During the dark ages ignorance and superstition blotted out all education and all desire for education among European peoples, the Moors of Spain alone excepted. Some remnant of learning remained in the monasteries, but it was only enough to accentuate the intellectual darkness which enveloped the nations.

The rise of the mediæval universities marked the revival of learning. In Paris, Oxford, Bologna, Prague, Vienna and many other cities were established great schools of the liberal arts, law, medicine and theology. The Trivium and the Quadrivium were still the principal subjects studied. Learning was surrounded by a high wall and the only entrance to the sacred enclosure was through the Latin gate. All books were in Latin; Latin grammar and rhetoric were first studied. Pupils slowly repeated grammatical rules recited by the teacher and then learned by rote the works of the classic authors. Dialectics next received attention and pupils spent years in wrangling in Latin over disputed constructions in grammar or knotty points of law and theology. There was no vernacular literature. The lore of the ages had been concentrated in Greece and Rome, and though these countries were now shorn of their ancient splendor, they still dominated the world of learning. This was but natural, as the languages of western Europe were crude and unformed, while the classic tongues were polished and refined. Latin was the language of the educated; a knowledge of it opened the door to all art, literature and science. It was the badge of an aristocracy, a secret brotherhood of learning. Those within the order had certain privileges not possessed by others and they looked down upon those outside their ranks. The education of this period lifted men out of the ignorance in which they had been engulfed for centuries and gave them all the knowledge of the world. This knowledge was centuries old, it is true, but it was fresh and new for those who had rediscovered it. They churned it over and over, pressed it into

new forms and expressed their wonder and admiration at the beauty they found in it. But as a rule they made no effort to improve upon it, to discover new truths or to impress their own thoughts upon the world. The student who receives all his knowledge in a foreign tongue, different from the language of his every-day life and thought will seldom add to that knowledge. Truth reveals itself to him who diligently seeks it at all times and places, whose every thought is given to the search and whose mind is open to receive it even when engaged in the most commonplace affairs of life. A man living in his native country thinks in his own tongue; if there are no words in that tongue to express the ideas which come to him, they are apt to pass unheeded.

The dawn of the renaissance brought new factors into the intellectual life of Europe. The several languages settled into fixed forms and became more refined. Reading, writing and arithmetic were taught in the mother tongue and so education spread among the common people. Scholasticism gave place to classic culture and the study of history, philosophy and mathematics became more common in the universities. Latin was still the language of learning and the classic authors the chief source of culture. During the centuries which have followed, the changes in methods and subjects have been slow. In the past the teacher has been the most conservative of men. He has taught that which he himself learned and has followed the methods of his teachers. Education has been a rigid mold, a cast-iron form into which all were pressed and came out exactly alike. All culture and the greater part of learning were embalmed in the classic tongues and these mummified forms were thought to be eternal and unique. But the spirit of scientific enquiry has shattered the mold and one subject after another has been added to the curriculum of the university. Men have come to see that language is a means and not an end; that the true subject for study is not grammar, but the universe. It has taken many centuries to show that education is many-sided and of many forms. Until within a few years the curriculum at each college has been fixed—so much language, so much mathematics, so much philosophy, so much or rather so little science. The student who had no taste for mathematics was forced to do as much as the one whose taste was for formulas and numbers; he who disliked language must cram Latin and Greek for years or he could not be called an educated man. But new ideas and new methods have come within the last half century. It has come to be recognized, the advocates of the new method say, that all men are not alike, that what is suitable to develop the mind of one will not answer for another. Individual tastes and capacities have been at last respected and no student is now forced to try to become a linguist or a mathematician or a philosopher or a scientist or a weak combination of them all against his wishes. The educational pendulum has swung from the conservative to the radical side and now the student may decide to specialize in chemistry, or logic or Anglo-Saxon before he knows what these terms mean. In some respects we have reverted to the methods of the mediæval universities, for now as then a student may graduate without much knowledge of his mother tongue.

Which of the methods so hastily mentioned has produced true education and which results shall we use to settle the question under discussion? Is the true method that of the Chinese which taught a worship of ancestors and a reverence for antiquity; or that of Persia and Sparta which prepared men for war; or that of Athens, which in the words of Milton

'taught men to perform justly, skilfully and magnanimously all the offices, both public and private, of peace and war'; or that of ancient Greece and Rome which developed an almost perfect language and literature and produced an art and philosophy which have been the admiration of the ages; or that of the mediæval universities which revived a part of the old learning but added nothing new, or that of the centuries succeeding the renaissance which laid chief stress upon classic culture but developed a vernacular literature and gave birth to the sciences; or that of the present with its tendency to absolute freedom in the choice of studies? Among this diversity of methods and results it is difficult to select a criterion by which to settle our question. Many definitions of an educated man have been given, but among them all I know of none that will appeal to a scientific mind like that of Huxley. He says: "That man, I think, has a liberal education, whose body has been so trained in youth that it is the ready servant of his will, and does with ease and pleasure all that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength and in smooth running order, ready, like a steam engine, to be turned to any kind of work and to spin the gossamers as well as forge the anchors of the mind; whose mind is stored with the knowledge of the great fundamental truths of nature and the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions have been trained to come to heel by a vigorous will, the servant of a tender conscience; one who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to esteem others as himself."

Without attempting to rival this and other definitions, I may say that considering the subject from an intellectual standpoint only, if we are to train educated men I believe we must teach our students to know, to search, to think. To know—what? This is the question which our institutions of learning have been trying for many centuries to solve. When all knowledge was embraced in the Trivium, the problem was easy. He who mastered the Trivium was educated. Now the very extent of knowledge makes the problem difficult. The chemist, the mathematician, the botanist, the philologist, each declares that unless a man knows something of his specialty he is not broadly educated. Enough is known in mathematics to keep a student busy for his entire life, and the same is true of all other branches of learning. The poor student is urged on by one teacher and conditioned by another, is given lessons by each long enough to consume all of his study hours, and wonders why he is obliged to try to master things he does not like; or turned loose to browse as he pleases, seeks too often the easiest paths and gains but one side of an education. No man can know all there is to know. However great his attainments, however broad his sympathies, however brilliant his intellect, he can only prospect a little on the mountain of knowledge. Is it necessary to know all? Are there not some things a knowledge of which is necessary in education, and others which can be left to the individual taste? I believe that in the future all colleges will answer this question, as some have already done, in the affirmative. Those which still adhere to the required curriculum must permit a certain amount of natural selection, while those which offer almost absolute freedom in choice of studies must place more restrictions upon youthful tastes. And what are these necessary subjects which all should master? First and foremost is one's own language. The ability to speak and write the mother tongue should be insisted upon

in every scheme of education. It is evident that the secondary schools can not complete this work. The entrance examination papers in every college show that the students know very little about rhetoric and composition. It is a slow process to teach a student to express himself clearly, concisely, elegantly. Cato said, 'Get a firm grip on the matter and words will follow fast enough.' This may have been true two thousand years ago, but either it is not true to-day or our students do not conform to the condition. The English language should be studied from the time the student enters college until he leaves if he is to be master of his own tongue. Modern languages, two at least, should also be insisted upon. Knowledge is not circumscribed by boundary lines nor learning located by latitude and longitude. No one country, no one language contains all the educated man should know. The study of literature will naturally be coincident with the study of language. The great thoughts of some of the great men of all ages should be known and understood. The range of reading should be wide, the critical study of style and content be confined to a few authors. History should be included in the list of necessary subjects. The history of one's own country should be well known; the history of other countries restricted to the most important events. Most of our college students have not studied American history since they were in the grammar schools and few if any of our colleges make it a required part of the curriculum. Can any knowledge be more important to the educated man than the history of his own country, and is the amount acquired in the grammar school before he is fourteen years old sufficient? History should not be confined to great events or to the manners and customs of the people, but should include past and present politics. Many years ago there was inscribed upon the walls of the historical rooms of Johns Hopkins University the words of Freeman, 'History is past politics; politics is present history.' Past and present political parties, the principles they have or do stand for, the success or failure of their policies and their effect upon the welfare of nations, may well be required. The study of civil government is closely allied to the preceding. Very few of our college students can describe the government of the cities in which they live or tell the names and functions of the several courts of justice in their native states. Economics, though not a required study in most of our colleges, is one with which all should be familiar. The functions of land, labor and capital, the relations of labor and capital, the nature of supply and demand, money, production, distribution, wages, rent, taxation, tariff, should all be understood. Philosophy and ethics should, I think, receive a small amount of the time devoted to required studies. Nor can a man be called educated unless he knows something about art. The several schools of painting and sculpture, the great paintings, the great statutes, the masterpieces of architecture, should all be familiar to the student. Chemistry and physics have made the wealth of our modern world, have revolutionized our mode of living, have dictated the policy of nations and have changed the course of history. Yet how few of our institutions of higher learning require either of them except as entrance subjects? There is very little in mathematics which is necessary for the educated man to know. Arithmetic, algebra and geometry are studied in the secondary schools and from the standpoint of knowledge nothing else need be required.

Botany and astronomy are likewise necessary. The educated man moves among the trees, the plants, the flowers, by day, and

sees above him the planets and constellations by night. No more than in the days of Job may he bind the sweet influences of the Pleiades or loose the bands of Orion, but he should know the north star when he sees it and be able to tell why the Copernican theory is true.

Am I requiring the educated, the broadly educated man to know too much? He can learn something of all these subjects during his college course and yet have a great deal of time left to follow his own individual tastes. The standard by which to judge the technical course, to ascertain its deficiencies, must be broad. In these days of telephones, electric cars, X-rays and the wireless telegraph ought we to call a man educated if he has not given considerable time to the study of physics? Ought we to call a man educated if he does not know the history of the great political parties and our methods of government? Ought we to call a man educated if he moves among the phenomena of nature by day and by night with no more knowledge of them than if he were blind? And yet we are graduating from our colleges many men who know little or nothing of any of these subjects and we do call these men educated. The educated man is to live in his own generation; he is a citizen of to-day, not of yesterday or to-morrow, and he should know those things which will fit him for the business, social and political life of his own time.

To search. However much a man may know, there is yet more to be known. It is not necessary for the educated man to know everything, but it is necessary for him to be able to find anything in the realm of knowledge. He should be taught how to use indexes, dictionaries, encyclopedias and other books of reference; libraries, art galleries and museums should open their stores to him when he bids them. Every one knows how to look up a word in a dictionary or an article in an encyclopedia, but the systematic use of all sources of information is rarely taught. The student has not been fully initiated into the mysteries of his order until he has been taught to search. Then the freedom of the scholar is his and the universe lays its treasures at his feet.

To think. The most important and the most difficult! Man may be by nature a thinking animal, but if so, he does his utmost to conceal his powers. The faculty of original thought never comes to most men. In childhood we must accept what is told us, and we become so accustomed to receiving our ideas from others that many of us never outgrow it. We believe without question what we read in books, magazines and newspapers, what we hear in the classroom and from the pulpit and platform. But the broadly educated man must think for himself. The mind, like the body, should be put through certain exercises to gain strength. Mathematics and the ancient languages, which have been omitted from the list of things the educated man should know, are among the most powerful influences for training the mind. This is why they have held such an important place in the curricula of our colleges. But they are not the only subjects which will stimulate mental thought and teach the mind self-reliance. A man may grow strong by rowing, by using chest weights or by chopping wood. Any one of these will stimulate the nervous system, send the blood to all parts of the body and keep every muscle in a healthy condition. The proper study of chemistry or philosophy or thermo-dynamics will have a like effect upon the mind. But there are many muscles in the body; if a man uses his biceps only, he will not grow strong in the legs. And there are many powers of the mind. If the intellect is to have all its powers of equal strength, as Huxley advises, the man must be taught to think in

more than one direction. He must study language, mathematics, science, philosophy, not for knowledge only, but for discipline.

If these requirements, which, I confess, have a large personal equation, are necessary to produce education, does a technical course educate? Perhaps it would be proper first to inquire: do our colleges and universities educate? Do they teach their students to know, to search, to think? Have they not gone too far in the direction of allowing any man to study anything? But it is the technical school and not the college which is under discussion. The technical school is a professional school and its duty is to train its students for active professional life. It is not a university nor a college. Its aims and its methods are different from either. Its business is to teach, and if it does not teach, it has no excuse for existence. In a university, the faculty are expected to do little teaching and much research work; in a technical school they are expected to do much teaching and little research work. Research and expert work are advisable to a limited extent—limited, however, only by the time and strength the instructor has left after his regular work is done. They should be encouraged by the authorities in every possible way under the above restrictions. Research work is the legitimate outcome of learning to think. He who possesses the power will find ways and means to use it. Coal burned in our furnaces yields but a fraction of its energy in useful work; the sun's rays shining upon the roofs of our manufactories have stored up energy enough to light and heat the buildings and to operate all the machinery within, but we use none of it. Surely there is opportunity for original work by the engineer. The community has a right to demand that the professor in a technical school shall do expert work. The knowledge he possesses, the laboratories and apparatus at his command should be for the use of the community whenever this will not interfere with his first duty as a teacher.

Engineering is a learned profession. Schools of law, medicine and theology do not attempt to give a broad education. They either require a liberal training for admission or they admit students from the secondary schools. In both cases the course of study is the same. The engineering student usually comes directly from the secondary school. It would be possible to give him drawing and shop-work at once, to furnish him with tables and empirical formulas and have him begin technical work immediately. But this would make him a mere machine and not an educated engineer. The technical schools recognize that they are training for a learned profession and require the students to give the greater part of their time for two years to liberal studies. The purpose of the Roman schools was utilitarian, but they furnished a sound training. The purpose of the technical schools is likewise utilitarian, but they give a broad and liberal education as far as they go. English is thoroughly taught during the time devoted to it. The training in modern languages is good, although its chief aim is to teach the students to read scientific books and periodicals. Mathematics is thoroughtly taught; it has to be for it is the basis of all engineering work. Physics and chemistry are required to a greater extent than in any college. Economics is required in some and offered as an elective in many others. The technical student is taught to search. Books of reference, periodical literature, proceedings of societies and government reports are made a part of his education. And an effort is made to teach him to think. The connection between theory and practice can only be learned by vigorous mental effort. It is only by right thinking along scientific and mathematical lines that the

student learns to transform a theorem into a dynamo or a formula into a compound engine.

And thus I am led to the conclusion that a technical course does educate to a limited extent. It teaches the student to search and it teaches him to think; it teaches him some of the things that an educated man should know, but it does not teach him all that an educated man should know. It would be much better if our technical graduates were broadly educated men as well as trained engineers, if they had received a college training before entering upon a technical course. In a university it would be easy to require this. Two courses would be open to the student. He could complete his college work with no reference to technical subjects and then enter the engineering department; or after completing those subjects which are considered necessary for a liberal training, he could choose a part or the whole of his electives in the technical school. In the former case his combined college and professional course would require six or seven years; in the latter case five or six years. Some of our universities have such a requirement and I am glad they do. I believe the student should be trained to know, to search, to think before he enters the technical school. During his whole life he would have a broader outlook, a deeper sympathy with men and events, a greater influence upon the community. I am not sure that he would be a better engineer.

But however desirable such a combined course may be, it is not possible at present to make the whole or a part of a college education a requisite for admission to the technical schools. In 1902 there were graduated about 1,600 engineers; there was a demand for about 4,000. If a college diploma were required for admission, the number of graduates would not be more than a quarter as large as now. Even if it were possible to make such a requirement, I do not think it would be wise to do so. Whatever may be our opinion in regard to the best course of study, we must take into account the wishes of the student and the average technical student does not wish to go to college. He thinks the course of study too long and too expensive. He would be forced to give up all hope of an education if six or seven years were necessary to obtain it. A man's first duty is to make a living for himself and for those dependent upon him. The average boy—your boy and mine—has his own way to make in the world. He will be given an education but after that he must take care of himself. The technical course, if understood, is wonderfully attractive to the boy. The Talmud says, 'the end of learning is doing'; the end of a technical course is doing and the average boy wants to do something. He knows he can make a living as soon as he graduates. It is not strange that he wishes to begin this work as early as possible and to finish it as soon as consistent with thorough preparation for professional duties.

In conclusion I would say that the technical school has three great duties to perform in education.

First: To maintain a high standard in its professional teaching. It was created to do this work. Technical training is education of a high order, although not liberal. The mistakes of the engineer are destructive to property and sometimes to human life; hence the standard of teaching should be high.

Second: To see that it does not degenerate into a trade school. The student will go into practical work when he graduates and so there is a tendency to give him more and more practical work in the school. There is no objection to this, provided it does not interfere with the broader studies already described. If the liberal studies

usually given are dropped, the technical school will become a mere shop or drafting room.

Third and last: To encourage those young men who are planning to enter technical work to first obtain a broad and liberal training to the end that they may be better citizens and wield a greater influence in society, the community and the state.

CHAS. S. HOWE.
CASE SCHOOL OF APPLIED SCIENCE.

THE WORK OF THE BUREAU OF GOVERNMENT LABORATORIES, OF THE PHILIPPINE ISLANDS.

IN an article published in a former number of SCIENCE* a short résumé of the plan which had been devised to further scientific work in the Philippine Islands was given, together with an outline of what the bureau of government laboratories expected to do in the future. At that time the organization had only begun, and the scientific work which was being performed was limited. Plans for a new building were under way, and an attempt was being made to obtain a large corps of scientific workers to carry on the necessary research work for the government, but only a few men were actually on the ground. Two years have now elapsed, and it is possible to speak with certainty of the results accomplished, and with confidence of the scientific scope of the future.

The new laboratory structure, planned carefully in the beginning, is now approaching completion, and the adaptation of this building to the needs of the varied scientific work to be carried on can be appreciated. The branches of chemistry, bacteriology, pathology, botany, entomology, as well as the preparation of prophylactic and curative serums, have been amply provided for. Although it can already be said that each room will be occupied, there will, nevertheless, be no crowding for years to come, and only two or three workers on specific subjects will need to occupy one room at a time. The building has been somewhat delayed, not only owing to uncertainty as to its location, but also because of lack of some of the materials necessary for its construction. The machinery which is being installed will be ample for the purposes of laboratory technique. It will supply compressed air, vacuum, steam and steam exhaust, as well as electric power in all of the rooms and at all of the desks where such aids are necessary, and the pressure, mechanically provided, will give an ample water-supply for all parts of the building.

One difficulty encountered in laboratory work in the Philippine Islands has been in the gas-supply. Owing to the nature of oriental coals, it has not been profitable to construct municipal gas plants. The price of the coal which can be obtained is high, and the products are not such as to yield large quantities of illuminating gas, and obviously the importation of the proper materials from Europe or the United States is out of the question. Gasoline, which is used so frequently for laboratory supply in other countries, is both expensive and of an inferior quality, and for this reason the bureau has adopted the method of preparing its gas from cocoanut oil. Heavy cast-iron retorts are heated to redness in furnaces, and cocoanut oil is then slowly dropped in. The product is a very high quality of illuminating gas with very little tar and a proportionately small residue in the retort. In the new building a battery of three of these generators will be installed, and provision will be made for the putting in of a fourth unit, the capacity of the gas-holders being 2,500 cubic feet.

The bureau, as at present organized, is separated in three buildings, one for the work in chemistry and botany, another for

* SCIENCE, October 10, 1902.