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CONTENTS:

<i>The Cultural Value of Engineering Education:</i> PROFESSOR FRANK O. MARVIN.....	121
<i>Physical Chemistry:</i> PROFESSOR J. H. VAN'T HOFF.....	126
<i>Psychology and the Medical School:</i> PROFESSOR GEORGE V. N. DEARBORN.....	129
<i>The Botanical Work Committee.....</i>	136
<i>The Function of the State University:</i> PRESIDENT R. H. JESSE.....	138
<i>Scientific Books:—</i>	
<i>Bigourdan on Le système métrique des poids et mesures:</i> DR. T. C. MENDENHALL. <i>Lyons on Electromagnetic Phenomena:</i> PROFESSOR M. F. O'REILLY. <i>Jordan and Kellogg on Animal Life:</i> S. H. G. General	143
<i>Scientific Journals and Articles</i>	149
<i>Societies and Academies:—</i>	
<i>The Onondaga Academy of Sciences:</i> H. W. BRITCHER.....	149
<i>Discussion and Correspondence:—</i>	
<i>The Larynx as an Instrument of Music:</i> PRO- FESSOR WILLIAM HALLOCK. 'Is Larvæ Conta- gious?' H. S. GAUS.....	150
<i>Current Notes on Physiography:—</i>	
<i>Glacial Corries in the Bighorn Mountains; The North German Lowland:</i> PROFESSOR W. M. DAVIS.....	152
<i>Museum Reports:</i> F. A. L.	153
<i>The American Chemical Society.....</i>	154
<i>Railway Time Table between the East and Denver...</i>	156
<i>Scientific Notes and News.....</i>	157
<i>University and Educational News.....</i>	160

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE CULTURAL VALUE OF ENGINEERING EDUCATION.*

AT the very outset of this discussion is encountered a great difficulty. What is culture? The writer has been asking this of his friends. An answer has been sought for in the printed page where is recorded the best thought of the best minds. Great thoughts and lofty ideals have been disclosed, but nowhere has been found a satisfactory definition, a phrase or paragraph that succinctly and clearly sets forth the heart of the matter.

People often recognize, appreciate and reverence its possession without being able to fully analyze and set down its elements. There is something subtle and emotional about it that eludes a close pursuit.

The reason for this perhaps lies in its essential individual quality, in its being the result of a personal life, developed, it is true, on lines similar to those used in other lives, yet including something that pertains exclusively to the human unit that is different from all other units.

Nevertheless, there seem to be certain fundamental qualities which must be possessed before a man can be classed with cultured people, qualities which are only acquired after a considerable experience in

* Address of the President of the Society for the Promotion of Engineering Education, Buffalo meeting, June 29, 1901.

life, but which are influenced greatly by the years of student training and therefore fit subjects for discussion here. Far be it from the purpose of this paper to attempt a definition of culture or a setting forth of its elements in any completeness; rather the emphasizing of some things that relate to it, especially with reference to the education of young engineers.

First: The man of culture must be a thinking and reflecting being. There must be not only the ability, but the habit; and this is no easy thing to acquire. Modern American life is full of hurry, full of affairs that demand instant attention, and one matter follows another with rapid succession. We get news from Peking to-day, from Havana to-morrow and from the Philippines within a few hours. We build railways, erect bridges and fill large orders for locomotives for foreign shipment in such short space of time as to astonish the world. Men seek short cuts to fortune. In the popular opinion, the men who act quickly, the men of decision, are those who succeed. But there is a danger here. For, back of the action, behind the sharp decision, must lie a mature judgment, and how else is this to be formed except as a result of deliberate reflection. However quickly one may reach a conclusion, its correctness or faultiness will depend not on intuition, but on the degree of true comprehension. The decisive act which is also right rests on a process of thinking and judging that has been long fostered, until it has become a habit, until there are established certain standards by which things are to be measured.

The early steps of this training are necessarily slow, and we, as teachers of engineers, must recognize this and not yield to the temptation to crowd our students over too much ground on the one hand, or, on the other, to lead them through short cuts across country by empirical paths that may give

them ease and quickness of travel, but little or no reason why the path is chosen. Let them go the long road. I do not by any means wish our teaching to be non-practical—rather more practical in the best sense; but first, last and all the time, let students be trained to do their own thinking and to form their own judgments; to test the statements of others by the workings of their own mental processes.

Second: There is another element of culture that comes in here, an ethical one, that of forming right judgments. Men may have the appearance of culture without its true spirit, which is essentially honest. This is especially important, as culture seeks to make a man's life satisfactory to himself when measured by his own conscience, as well as successful in the field of affairs. So his standards must be based on sound principles of right and wrong; and it is only when these are so placed that his life becomes one of freedom, freedom from the bondage that wrong thinking and acting always bring. A class room is no place to preach a sermon, but there can be there imparted a respect for truth and perfect honesty. A teacher's attitude should always be open and frank, that of a sincere seeker after truth. He should never dodge an honest question, and be ever ready to say 'I do not know' if he does not. There is an incalculable power that 'makes for righteousness' and the happiness of the after life of the student in the true teacher's conduct of even such a material subject as mechanics.

Back behind the subject with its subdivisions, its formulæ and rules, lies something larger, a sort of spiritual quality that binds it to all other subjects, to the universe as a whole, and makes it a part of the truth of God's realm. The student that gets hold of this significance learns much more than facility in the manipulations of processes or the application of principles. He gets some-

thing that makes his life richer and better and his mastery of the subject more complete.

Third : There can be no true culture for a man that does not work, that does not put his cultivated powers to some useful service : and here there must be such degree of mastery over the chosen profession or business as will result in a special skill and dexterity—a doing of some one thing better than others can do it. A man expresses himself through his work, and whether he will or no, he thus discloses to all who know him his own peculiar qualities. It is this intensity of application, this concentration of purpose and directness of aim, that gets the world's work done. Here in early years the engineering student has the advantage of the student in arts. Study for knowledge's sake may be stimulating to the few, but for the many there is needed the goal of a special calling to secure the close application that results in ability to concentrate one's energy to the attainment of a certain end. But here again comes a danger, that of too early, or over, specialization, and the following of short cuts to professional life that are advocated by some who, in the eyes of the world as well as in their own, have been eminently successful as specialists. Whether these can be called men of culture of the highest attainments is another matter. The extreme specialist may be supreme in his own line of details, but may fail when there comes up a question involving the relation of his specialty to other things. Even within his own domain, his conclusions will be modified by his general knowledge and experience. All one-sided people, whether they be linguists or naturalists, poets or merchants, preachers or engineers, are quite liable to the forming of erroneous judgments. To the few geniuses, whose capacities and powers seem to be abnormally developed, though of limited scope, much is forgiven ; but for

the average man of the day there is demanded an ability to form good and wise conclusions.

Fourth : In order to form those that are appropriate and correct there is needed, then, breadth of view—a quality that has been expressed by the word *poise*. A man of poise, of even balance, will see things in their right relations and due proportions ; he will weigh matters, giving to each component part its just degree of importance. He will the better understand the motives that underlie other men's actions and the more readily use them to suit his own purpose. He will be more apt to rightly interpret the new movements in the world of thought or action and can seize opportunity for a personal advantage or a larger sphere of service before others see that there is such.

This demands a considerable range of knowledge. Not the close mastery of many lines in all their details, but a fair degree of familiarity with their general phenomena and principles ; and there is scarcely any field that will not contribute something to the result. It is admitted at once that the average man is of limited capacity and unable to grasp a comprehension of all knowledge that may influence his life and work ; what is pleaded for is such degree of breadth as may be needed to make one of great efficiency in his chosen profession and of most value to himself, not only in a financial way, but also in the sense of gaining a joyful recognition of the worth of developing all the powers that one has.

The value of mathematics and the physical sciences with their applications to technical things needs no discussion here, for these are the engineer's tools ; but it is a fair question whether, in our desire to graduate students that can be early useful, we do not place too much stress on technical things to the exclusion of others that give greater breadth of training. We must

not forget that we are educating men for a life; that we must look forward to the time when these young people will be fifty years old, and at the period of their maximum productiveness as workers and of maximum value in society and as citizens.

Engineers have to deal with other things besides materials and physical laws; they must manage men and matters of finance. If they are to rightly influence those whose capital they are employed to expend, they must be able to meet them socially and intellectually, to discuss intelligently matters outside the pale of strictly professional life. Evidence of professional ability and skill is of course first demanded, but breadth of culture creates an added confidence in the wisdom of the conclusions reached and the advice given.

Heretofore much of our engineering work has been concerned with the opening and developing of new country or new business and industrial enterprises. So engineers have found their work away from contact with men. But engineering practice is changing, as conditions become older and more settled, and more and more practitioners find their work in communities and busy centers of trade where they are constantly thrown into close contact with strong and cultured men. Present engineering courses do little to prepare a man for this thorough instruction concerning human nature and human relations. Something of history, economics and sociology should be included.

Fifth: It is not sufficient to form correct judgments only; there must be added a skilful and effective presentation of them in well chosen and fitting English. The ability to do this involves more than training in the writing of compositions, themes, forensics and reports. The cultured man should have a taste for reading the best that has been written in his mother tongue, and for several reasons: The great

thoughts of great minds are stimulating and broadening to his own mind; he thereby absorbs a knowledge of words and their shades of meaning; he gains an appreciation of style and insensibly better knows how to form his own; and, not least by any means, he makes of his books friends that are life-long, that cheer and console him under all happenings, adding much to his internal resources for happiness.

The time given to English in our courses is not enough to train students properly in its use and at the same time open the doors to our best literature. It may be said that all this English work should be done in the preparatory school, and it is probably true that the character and quality of the high-school English is better to-day than it has been heretofore. Yet it seems to me that engineering students should have some training of a college grade along the line of literature.

Sixth: To the writer's mind, there is another element of culture that should enter into an engineer's training, viz., an appreciation for beauty. As he has said at another time* the engineer is a designer, and it is important that he should embody his design in artistic form if he is to fulfil his whole mission and please and gratify others by the perfection of his work. The engineering student devotes a good share of his time to the drawing-board, and much can be done here toward the cultivation of this quality by an instructor who possesses it, without lessening at all the amount or force of the technical exercises for which the process is primarily used. There should be, however, something further by way of giving instruction in elementary aesthetics and by opening the students' eyes to what is beautiful in nature.

Seventh: The possession of agreeable manners and tact is another evidence of

* *Proceedings* of the American Association for the Advancement of Science, Vol. 45.

culture. Not merely the conventional bearing of polite society, though this has its value. This alone is but a husk which must cover the real kernel, refined and gentle feeling; and such feeling is the result of moral and intellectual convictions. Manners, then, are not to be taught from a text or by lecture; they rather follow as a consequence from the whole course of training and are crude or refined, just as the character of the instruction makes them. The teacher's personality has very much to do with this matter. If he is of coarse grain, of domineering or selfish disposition, his influence will not tend toward the production of true gentlemen.

And now for the real question—does engineering education tend to produce culture? According to old standards, when men limited culture chiefly to a knowledge of language, literature and philosophy, the reply would be in the negative. However, standards are not the thing itself, only methods of measurement; moreover, standards change. Science has modified and is still changing the ideas of culture that men hold, and this evolution makes it all the more difficult to find a common ground upon which all can stand when considering things concerning it. This much is clear, however, that no one existing course of educational training has a monopoly of cultural methods; nor will the completion of any college course necessarily secure its attainment because of its personal quality. Further, culture is the result of a life, and the most that can be expected of a college course is to open the students' eyes to its real worth, to start them rightly with certain leanings and aptitudes, and furnish them with the means of a continuous growth toward its maturity.

It is maintained that an engineering course can tend in this direction, and that in some of our best colleges, under the instruction of people themselves cultured,

it does so tend to-day. Our best engineering courses are stiffer and more exacting both as to time and effort than those in the college of arts, and the resulting acquisition of mental power and the ability to focus it proportionately greater.

The fixed course with its correlated parts and the certain definite end to be strived for are advantageous. The training is a continuous testing and trying of the truth of knowledge, and teaches the student to ask 'why' and to reflect. He gains respect for nature's laws, and learns that his professional success will depend on his ability to work in harmony with her. He gathers a fair degree of knowledge of himself, his strong points as well as his limitations. He acquires a habit of thought and action that leads to further growth. He learns how to adapt means to an end, and within what limits of precision to work that it may be reached with economy. In short, he becomes a trained and educated man, cultured to a certain degree, but with limitations; just as the arts student who has specialized to a like degree in language and literature, with little of science training, becomes cultured, but also with limitations. Let the latter retain his A.B. On the other hand, let it be recognized that the engineering B.S. stands for culture as well, of equal worth and value, though of different kind.

As between the two specialists, I think the advantage lies with the engineering graduate as being on the whole, better equipped for a life of useful service and one that will possess the greater capacity for further development.

As one looks forward ten or twenty years and attempts from present tendencies to forecast the work and social standing of engineers, he must see that the profession will be doing a larger work and exerting a greater influence.

Further, that an engineering training will be more and more recognized as the one best

fitted to lead to positions of an executive nature in connection with industrial enterprises, and in the administration of public works. Everywhere will be demanded expert skill, sound judgment and broad views, primarily because these will be found to be economical. The entire class of men that a recent writer has called 'mattoids,' the ill-trained, narrow and egoistic, will be pushed out because their service is costly.

There are two tendencies in the present-day engineering education that are, in my judgment, opposed to the desirable result. First, a tendency to crowd too much of the foundation work back upon the preparatory school, already overloaded. This Society's Committee on Entrance Requirements has advocated a standard which is high enough. Second, the allowing of technical subjects to crowd the fundamental general ones from the college course, in a vain attempt to do what from the very nature of the case cannot be done, make an engineer by college study. The result of this in some institutions is further seen in too early a differentiation between the various engineering courses; so that, for instance, the civil student knows nothing of applied electricity and the electrical student nothing of surveying, while neither has a chance to acquire a taste for literature.

The whole problem is an involved and complicated one, but there is a way out that must be found if the engineer is to fill the important place that awaits him. One part of the solution will be probably found in a refining of the methods of instruction, so that better results may be reached in the same time. In the end, however, the writer thinks that there must come a deeper sense that after all life is long, that it should be taken with more of deliberation, and that it is the end that is important, rather than the beginning. The feverish rush and haste to be earning must be re-

placed by a recognition of the real necessity for a full rounded-out preparation if the largest and best service is to be given. Then the student will be glad to spend the one or two extra years in college that may be demanded. The wise student now will do this without its being required.

The Chief Justice of my own State has said, "The spirit of an age is that which makes finally for the happiness of the race. I have absolutely no fear as to the final end of things, nor as to the steps and incidents of evolutionary development. The aspirations, the great universal possessions of a people, can never move them to other ends than their happiness and good. The spirit of this age is commercial enterprise and conquest, and as to it I have an unspeakable conviction that it will, as the spirits of other ages have done, work itself into forms and institutions of beauty and eternal worth to men."

It is largely through the engineer that this is to be done. The finest result requires the most skilful labor; the noblest workman demands the most fitting training.

Herein lies our responsibility!

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PHYSICAL CHEMISTRY.*

As I am to deliver in the course of the next few days a series of lectures upon some parts of physical chemistry in their details, I should like to use this educational conference as an occasion for presenting an introduction to my lectures.

I add at once that one of our best modern historians, Ladenburg, in his 'Development of Chemistry in the Last Twenty Years,' sustains that the more and more prominent position of physical chemistry characterizes the development of our whole chemical

* An address given at the decennial celebration at the University of Chicago, published in the *University Record*.