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What Is Best in An Engineering Education

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This article is meant to provoke interminable discussion, so beware!

No two persons have the same conception of education. One's idea of being educated will depend on his age, past experience, present environment, inherited tastes, acquired ambitions, and so on. No one has himself the same conception of education at the ages of twenty, forty, and sixty. If so, at what age is he best qualified to judge what is best in an engineering education?

I heard a professor say once, he thought the student knew best what he wanted. If this be true the wide-open elective system, from the first year to the last, should be adopted. If older instructors are better judges of student needs, then the policy of required courses is better. Since, at the age of twenty, I held the opinion of the professor above mentioned, let me give the result, more especially because some knowledge of a writer's personal experience and ambitions—including his later changes of mind—is necessary to better allow for his personal bias. Therefore in brief:

Upon graduating from High School* my ambition was to follow some calling which required no further schooling. I was tired of books and wanted no more book-learning. I entered a county surveyor's office, beginning as "peg-whacker," was promoted to flagman, then chainman, then level-rodman; became curious about the instruments and learned to run the level and the transit. All this, including ordinary drafting, I did well at the end of the first year, and it would have cinched my education and self-satisfaction, if we had not added a college graduate to the corps in the spring—the only college man in the office.

I could beat him running the instruments,—for example, could set up the transit over a tack, with zeros together, in a minute while it took him five or more—could beat him at drafting, and also at arithmetic, for, having had a little trigonometry in the High School, I had practiced on latitude and departure during the winter and was better in arithmetic then, than I am now. But he raised disquieting questions. Talked about methods I had never heard of, spoke of unheard of subjects he had studied, and said, "high school wasn't a patch on college." Curiosity is one of the prime movers: I decided to go to college.

But only for a year or two, just to get the meat out of the course, and no more. I was not

*I secured work, (10 hours a day, 6 days a week, at \$2.50 per week) before the end of the junior year, expecting it would keep me out of school for good, but the job "played out" and I had to return in the fall, and finish my High School course.

willing to waste time on frills. Give me no French, English, chemistry, or such like—so they fixed out a class card marked "Special," with freshman mathematics, sophomore engineering, drafting, physics, and geology.

I nearly failed out the first term because of the "non-practical" subjects, and "non-practical" parts of the practical subjects. For instance, at the outset in freshmen mathematics, they were reviewing De Moivre's theorem and Euler's series before taking up spherical trigonometry. Was this not insulting to an expert in solving right and oblique triangles, who had never previously heard of nor had slightest need for Herr Doctor Euler or M. De Moivre? It was three weeks before I knew what they were talking about. Then physics—well, with an old dry-as-dust text book, I conditioned the first term, merited the second, (because I had to in order to stay in college), and failed the third term entirely—lost interest in the "non-practical stuff" and wanted to be off on surveys down south. School was run on the three-term plan, then.

At Chattanooga fortunately, during the year following, I met able men,—members of the American Society, who, not by precept but by example, aroused my ambition. So I came back to finish, and although illness kept me out another year,—spent mostly in railroad work in the West and geological work in Ohio—had the satisfaction of getting a sheepskin.

Witness the result of this early-held theory, that only the practical was worth while. Owing to small attendance then, the faculty permitted me to take "special" work, and I put off the cultural subjects as long as I could when they finally had to be taken—like a dose of spring medicine—to get my degree. I had gotten the meat out of the curriculum and wasted no time on frills; in "technical" language, had "got away with the bacon." Certainly I escaped English, French, chemistry, physics, and other subjects which I thought "non-practical" then, with only slight scars.

That has been twenty odd years ago. How much my opinion has changed may be judged from what follows. I have much regretted the results of my first-held theory. For one thing, it has kept me busy in spare time trying to make up deficiencies; some of this trouble would have been remedied by taking a degree regularly in course. For a second thing, I have never felt that I had a college education. It must be some satisfaction to complete a logical arranged curriculum, and not muddle through a hodgepodge. I say this, for my chief satisfaction now comes in trying to do

well what is worth doing at all. I don't always succeed, but hope to raise the percentage.

One ought to accumulate some satisfactions, during four years in college. Make some merits, high passes, *some thorough studies* of some of the subjects, no matter what, taken in college. Not that one brags about these later, or that they will make heavy contributions to one's learning or finance. But in private, in case of need, you can get out a few remembrances of good deeds, polish them up, and recall the old miner's tribute to his dead mule, "He done his derndest, no angel could hev done more." This private reflection furnishes "pep" for the heavy task that may confront you.

But, let us hope one is graduated with some dissatisfactions. One doesn't merit every subject he takes, nor take every subject he would like to have studied. This is fortunate. Dissatisfactions constitute a valuable asset—the most valuable, provided they are accompanied by the right spirit, an ambition to properly remedy them.

It's queer what trifles one remembers from college. I see clearly, after the lapse of twenty-odd years, the face of an old Episcopalian minister who spoke one day in chapel. He was devout by nature apparently, for he kneeled on the rostrum in the short prayer preceding his address. He was looking back past fifty years of ministry to his college days, and regretting—vainly regretting—that he had not been able, through financial straits, to complete his college course. He had grown gray lifting parishioners out of their sloughs, which left him not leisure to finish the subjects upon which his mind had still remained curious. But, he said, he rejoiced that he had all eternity in which to repair deficiencies.

In a nut-shell, let me register what I think at present. I would now list the chief benefits to be acquired from an engineering course as follows:

1. Habits of industry.
2. Aptitude at observing things.
3. A desire to think for one's self.
4. Willingness to attempt severe problems.
5. Power in attacking such problems.
6. Admiration for order and completeness.
7. An idea of how much one doesn't know.
8. Sources and methods of getting information.
9. Technical skill and information.
10. Candor.

This list is not rigid, but is as I see it at present. The last item should probably be stricken from the list. It should come first, were it possible to acquire in an engineering or any other college. However I believe that the engineer stands good chance to attain it, for he more patiently checks theory against fact and thereby should more clearly see human fallibility than do some of his brothers. But the quality is probably chiefly inherited. It is a charming trait, especially when coupled with the second and third in the list, and will carry one far in such case.

But what is now remarkable to me is that—making the exclusion above—I now list last, what I put first years ago. Do not misunderstand. I believe one should acquire as much technical skill and information as practicable in pursuing professional courses. But nearly every young student overemphasizes practicums to the injury of what is more important in college.

Furthermore, I would subdivide the ninth item in the foregoing list in a way I would not have admitted at first, on the theory that I hold now, which is, "get in college what you can't well get outside." That is, there are parts of technical skill and information which can better be had in college, and other parts that can better be learned out in practice. Let us subdivide technical skill and information then as follows:

1. A vocabulary in engineering technology.
2. A start in the use of correct English.
3. Proficiency in drafting as a language.
4. Power in the use of mathematics.
5. Fundamentals of chemistry, physics, and mechanics.
6. Principles and processes of his special subjects.
7. Cognizance of the worst mistakes often made in them.
8. Skill in using professional instruments and methods.

Not that the above order of importance is final, but again I put last what I first thought most needed, and nothing more. The first five are the most important. Here is where the skillful teacher of applied science has great opportunity; in using the last three to deepen the students' interest while he quietly rubs in the first five in disguise. For example, railroad surveying is freshman mathematics disguised in the clothes of rails, frogs, switches, spirals, and earthwork; with transit and chain, ax and pegs, for chalk and eraser, and campus for a blackboard. It lends romance to circles to call them curves—whether simple, reverse, or compound and to spirals to call them easements or tapers, and run in ordinary "eleven dollar" parabolas disguised as "vertical curves" with level and rod. Now please don't reveal this masquerade of freshman mathematics to sophomore civil engineers.

Not that I don't believe in handling the instruments as well as may be in college—such facility enables one to see theory more plainly, if he has his eye on the main point. Besides, an engineer is one who does things, and manual dexterity gets him a hearing, and makes him immediately valuable. I believe in training the hand along with the mind, for too many reasons to discuss fully here. But the college graduate can get a hearing easily now, even if he has not much manual dexterity, if he has other "entrance requirements." It was different twenty-five years ago; but now manual dexterity, although desired, will be waived

by discerning employers if other "entrance requirements" are present. I mean by the latter, honesty, good health, willingness to work and learn, determination, and some capacity to judge.

I know that many students have borrowed money to go thru school, and facility—dexterity—will place them higher in the salary list after commencement. But, alone, it will not keep them high in the list, as salaries go some years later. This gives rise to a suggestion I have always thought good. Why not mix outside practical work along with the college course? Not by trying to carry both at the same time, for thereby one or the other or both will suffer. But, if the student is of intensely practical turn, let him alternate practical work with college studies, a year at a time on each.

The stock objection to this plan on the part of the student is that it prolongs the period of schooling too long, and thereby costs too much. I believe this is not so much a condition as an "attitude of mind." For example, the one of my present senior class that I suspect of having least financial resource, has been in college six years, having taken an Arts degree in that time. He has worked his way thru both curricula by tailoring. Commercialism is the "attitude of mind" that blinds us all to the fact that education is a process of growth, and takes time.

For law or medicine the student may not plunge directly from high school into professional study, but must take pre-medical or pre-legal cultural work for maturity. In engineering, as matters now stand, the immature student may plunge at once from high school into a stiff professional course, and soon get mental indigestion. Let the engineering student get his maturity on practical work in the way suggested or otherwise, if he will not take further cultural studies upon graduating from high school. I found out that high school was "only a patch on college."

But even for those matured by concurrent practical experience, cultural subjects should not be omitted from engineering by crowding specialties into the four-year course; not unless we want to give up the idea of making our calling professional instead of making our graduates highly trained technicians. This is the consensus of all the opinion I have lately seen in the technical press—from men who have been out of college some time and have found great needs. While the young engineer, for five or even ten years after leaving college, may be working in purely technical fields, if he keeps on rising he will have to deal more and more with men as wise or wiser than he, and will need some common interests and view points. How will he find a meeting ground if he omits all cultural fields they have traveled?

I would defend cultural subjects on other grounds still, which may be called purely practical. I think I notice some of our seniors going a

bit stale—like over-trained athletes—on our over-technical four-year courses. Language, literature, history, pure science, and art (be it ever so little—as free hand drawing, photography, etc.) are cut to the bone, to give room for technical studies demanded by commerce, all to be crowded in a four-year course. The student starts in at break-neck speed, and gets winded before he has finished four laps. Breathing spaces, refreshment, should be provided on the way. It isn't the distance but the pace that kills.

What will the student fall back upon for mental relaxation in future? I know that some of the things tried furnish no lasting satisfactions. Shall literature, language, history, music, pure science, philosophy, art, *all* be closed doors to the engineer? Shall he have no inkling at all that "beyond the Alps lies Italy?" Shall he climb no peak however small, to glimpse the far-spreading realms?

Let me illustrate. I can begin to see with new light a subject I once saw as a mere string of facts—history. I have been reading Carlyle's "Frederick the Great"—for one thing, to learn how William II, the present kaiser, has come by his "divine right" ideas. Take one incident from the biography. Have you an idea of how drastic—appalling—a "technical" course young Frederick was put through between the ages of ten and twenty? It is morally certain he could not have kept his spirit from sinking utterly, if he had not had recourse to music, literature, and language—surreptitiously followed, because his father abhorred non-practical subjects and forbade them. Read only the first paragraph on Frederick II in Encyclopedia Britannica, to get an inkling of the harrowing picture given in detail in Carlyle's great work. Few mortals will work on harder problems than engaged Frederick until he was sixty, and few will be able to delight themselves through life as he did with the arts that buoyed him up daily for the arduous duties of business and state.

But, let us take a modern instance. To be up to date, take the last number of a well-known weekly* which lies on my desk as I write. It gives a short sketch of a Philadelphia lawyer, lately deceased. He was the son of a blacksmith,—his mother a milliner—so time, place, and environment were as different as may be from the instance just cited in the paragraph above. He early became interested in pictures, and at his death his collection of paintings was stated by experts to be unsurpassed in intelligent variety and taste. I suppose he would be called successful in his profession, for he was worth a number of millions, and was said never to have charged exorbitant fees for his services. I imagine his "hobby"—if such you will call it—furnished the buoyancy that won him success in his arduous

*Literary Digest of May 5, 1917.

tasks in law. It was the kind of a hobby that wore well for life.

We thus come around in a different way to the place where we started. Should the engineering student prepare to live twenty, forty, or sixty years after leaving college? If he expects to follow his calling only five or ten years after commencement, I would say reverse both lists that have been previously presented, and put the second list first in importance.

But I wish you long life, and prosperity, and I think we should all plan for it, no matter how early the fates be unkind. Such being the case, I will have to confess this discussion is subject to change. I hereby reserve the right to make a few changes of mind between now and the age of sixty. What are you going to do between the ages of fifty or sixty and eighty? There is the rub. If you build for just ten, twenty, or thirty years after college, what will you do with an additional twenty or thirty?

Here is where you will have to revert to your dissatisfactions for comfort. That little glimpse you got into geology in college, does that not make you want to travel that realm whose eons of time that are past, have left their records in rock pages that he who runs may read, if skilled. You say these things can be acquired after college. I say the chances are ten to one against adequate acquirement unless some real *work* was done on the subject in school. I studied geology three or four terms, was on several geological surveys, and find my appetite keener thereby to study this subject when leisure shall offer.

I have no quarrel with the talented person who finds in his technical work sufficient delight. Mr. Edison, at the age of more than seventy, finds technical work all absorbing and still works inordinate hours without other mental stimulant. But the average person has social, political, or aesthetic instincts—to say nothing of religion—and no matter how deeply buried, they sooner or later ferment for expression. The fields I have mentioned are cheapest to travel and yield most durable satisfactions.

Last but not least, physical health is essential in engineering. With some other professions it may not be so strikingly true. Your college course is not worth much if you ruin your health, which is another reason for going more slowly through college. Some health-giving habits are worth many studies and a reasonable fortune, and above all don't lose your grip on your sense of humor.

You see I have dodged the question—all the way through—of giving you the detailed specifications for "What is best in an engineering education." The means of deciding this question are given in the two closing paragraphs herewith. Having "started the ball rolling"—aroused discussion as I hope—let me close in lighter vein by quoting a delicate and touching poem from

Shakespeare, let us say from that portion of the great poet's works written by Lord Bacon.

"Educated for Life."*

Just after the board had brought the schools up to date,

To prepare you for your life work
Without teaching one superfluous thing,
Jim Reilly presented himself to be educated.
He wanted to be a bricklayer.
So they taught him to be a perfect bricklayer
And nothing more.

He knew so much about bricklaying
That the contractor made him a foreman.
But he knew nothing about being a foreman.
So he spoke to the school board about it,
And they put in a night course for him,
On how to be a foreman
And nothing more.

He became so excellent a foreman
That the contractor made him a partner.
But he knew nothing about figuring costs,
Nor about bookkeeping,
Nor about real estate,
And he was too proud to go back to night school.
So he hired a tutor, who taught him these things.

Prospering at last, and meeting other men as
wealthy as he,
Whenever the conversation started, he's say to
himself:

"I'll lie low till it comes my way—
Then I'll show 'em!"
But they never mentioned bricklaying,
Nor the art of being a foreman,
Nor the whole duty of being a contractor,
Nor figuring costs, nor real estate;
So Jim never said anything
But he sent his son to college.

No article is complete without proper references for further reading. Those desiring to decide quickly, what is best in an engineering education, are referred (1) to the recent hundred-page booklet of the Tau Beta Pi society, entitled "What Is Best in an Engineering Education," of which copies may be had free by addressing Prof. H. H. Higbie, University of Michigan, Ann Arbor; (2) to the forthcoming report on this subject by The Carnegie Foundation for the Advancement of Teaching; (3) to the 24 volumes of the Proceedings of the Society for the Promotion of Engineering Education, containing about 5000 pages of discussion.

Those desiring to make extended or more leisurely studies are urged to whet their appetites on a few miscellaneous books—such as "What Knowledge is of Most Worth" (by Herbert Spencer, who was himself an engineer in his early days), "How to Study," by McMurray, "How We Think," by Dewey—and then consult the library of the nearest College of Education.

*Professor John Erskine in the New York Evening Post.